Hastings Environmental Law Journal

Volume 20
Number 2 *Summer 2014*

Article 2

1-1-2014

The Draft Bay-Delta Conservation Plan: Assessment of Environmental Performance and Governance

Jeffrey Mount

William Fleenor

Brian Gray

Bruce Herbold

Wim Kimmerer

The Draft Bay-Delta Conservation Plan: Assessment of Environmental Performance and Governance

Financial support for this report provided by the S. D. Bechtel, Jr. Foundation
Technical support for this report provided by NewFields, Inc.

Jeffrey Mount, Ph.D. (Chair)

William Fleenor, Ph.D.

Brian Gray, J.D.

Bruce Herbold, Ph.D.

Wim Kimmerer, Ph.D.

Preface

The Bay-Delta Conservation Plan ("BDCP") is more than 15,000 pages long and covers a wide range of issues ranging from water supply, new facility construction, aquatic and terrestrial ecosystem management, governance and costs. Few outside of the handful of people deeply involved in BDCP actually know what is in the document due to its imposing size. This is particularly true for the various stakeholder groups who lack either the staff or the technical capacity to review the document and to evaluate the complex analyses that underpin it.

With support from the S. D. Bechtel, Jr. Foundation's Water Program, Saracino & Mount, LLC, was asked to assemble a panel of independent experts to review portions of the Plan to help guide decision-making by two non-governmental organizations: The Nature Conservancy and American Rivers. Guided by a narrow set of questions about how the Plan would impact water supply and endangered fishes, the panel reviewed the Plan documents and conducted analyses of data provided by the project consultants. The following document is a summary of our results.

It is important that this analysis not be over-interpreted. We do not endorse or reject the Plan. We only assess effectiveness of various conservation measures, guided by narrowly targeted questions. In addition, we make a handful of modest proposals to improve the performance of the Plan, particularly for issues of concern to the two non-governmental organizations. Thus, the scope of this review is quite limited.

The authors wish to thank the S. D. Bechtel, Jr. Foundation for its generous support. The staff of The Nature Conservancy and American Rivers provided abundant time and energy as we scoped this review. Jennifer Pierre, Armin Munevar, Chandra Chillmakuri, and Laura King-Moon provided voluminous data, answered our many questions and addressed our concerns. Spreck Rosecrans and Drs. Peter Moyle and Jay Lund provided comment on portions of the manuscript, although their comments do not constitute formal peer review. All errors of omission or commission are our own.

~Jeff Mount, Panel Chair

Introduction

The Bay Delta Conservation Plan—currently being negotiated by federal and state water managers, government regulators, water users, and environmental interests—is an effort to improve the reliability of water exports from California's Sacramento-San Joaquin Delta while continuing to ensure that those exports do not jeopardize the continued existence of 56 species of fish, other animals, and plants that depend on the lands and waters of the Delta ecosystem for their habitat and survival. The centerpiece of the proposed Plan is a set of two tunnels that would be constructed 150 below the islands and waterways of the Delta. Under the current draft BDCP, each tunnel would be 40 feet in diameter, and their combined capacity would be 9,000 cubic feet per second (cfs).

The tunnels would enable California's two largest water suppliers—the federal Central Valley Project ("CVP") and the California State Water Project ("SWP")—to divert Sacramento River water from three intakes in the north Delta for delivery to the CVP and SWP pumping facilities in the South Delta. From there, the water is transported to the South Bay, the San Joaquin Valley, the Tulare Basin, and Southern California, where it irrigates more than 3 million acres of farmland and supplies approximately 25 million Californians with water for municipal, industrial, and commercial uses.

Proponents of the BDCP—led by California Governor Jerry Brown—believe that the new tunnels would be a vast improvement on the existing conveyance system, which uses the channels of the Delta to move the water from the Sacramento River basin to the CVP and SWP South Delta pumps. They argue that "isolated conveyance facilities" would more efficiently transport the water across the Delta, protect the water both from contaminants and from salt water intrusion from San Francisco Bay, and better protect fish by allowing for North Delta diversions when endangered and threatened species are present in the vicinity of the South Delta pumps. Opponents are concerned that the tunnels would increase aggregate withdrawals of water from an already over-appropriated system and exacerbate stresses to the species and their critical habitat. They also question whether the costs of the tunnels and accompanying conservation measures—which the draft BDCP places at $24,757,000—is exorbitant in light of alternatives such as regional water stewardship, improvements in water use efficiency, increased use of reclaimed and recycled water, transfers of conserved and surplus water, and demand reduction.

If approved, the proposed BDCP would be a 50-year Habitat Conservation Plan under the federal Endangered Species Act and a Natural Community Conservation Plan under California law (the specific requirements of which are described in Chapter Two below). The Plan also would authorize the issuance of "incidental take permits" that would allow for the loss of (or harm to) a specified number of species protected by the federal and state Endangered Species Acts. In addition, the BDCP would provide the foundation for a biological assessment to support new biological opinions that would govern CVP and SWP operations in the Delta.

To fulfill the standards of these laws, the Plan must provide for the protection and conservation of all species listed for protection under the federal and state Endangered Species Acts, as well as other "covered species." The draft BDCP therefore includes 22 conservation measures, including limitations on the design and construction of the tunnels, constraints on CVP and SWP operations, and habitat improvements. This report evaluates some of the most important of these conservation measures and analyzes several significant questions of law and BDCP governance.

We prepared this report at the request of two environmental organizations, American Rivers ("AR") and The Nature Conservancy ("TNC"). They asked for an independent scientific and legal analysis of six specific questions, which are described in Chapter One. Although this was a commissioned work, and our primary purpose was to assist American Rivers and TNC in their own evaluation of the draft BDCP, our conclusions are our own—and we hope that they are truly objective and independent of the perspectives and positions of those who requested them. We thank the editors of UC Hastings West-Northwest Journal of Environmental Law for providing us with a forum to help disseminate our opinions to a broader audience.[1]

Executive Summary

Two nongovernmental organizations, The Nature Conservancy and American Rivers, are evaluating their options for engagement with the Bay Delta Conservation Plan. If approved, the Plan would become a Habitat Conservation Plan ("HCP") under the federal Endangered Species Act and a Natural Communities Conservation Plan ("NCCP") under California law. The purpose of the Plan is to allow for construction of new water diversion facilities in the Sacramento-San Joaquin Delta while also protecting aquatic and terrestrial species that may be adversely affected by the project and accompanying changes in the State Water Project and Central Valley Project operations. The Plan also includes habitat restoration and a commitment to assist in the conservation and recovery of species that are listed for protection under the federal and state Endangered Species Acts.

With financial support from the S. D. Bechtel, Jr. Foundation, Saracino and Mount, LLC, convened an independent panel of experts, with technical support from NewFields, Inc., to evaluate portions of the Plan. The panel, working jointly with TNC and AR, developed a series of technical and legal

1. This report analyzed the draft Plan that immediately preceded the Public Review Draft BDCP that was made available for public review and comment on December 13, 2013. Although there were changes between the two drafts, the issues that on which we focused our report have remained unchanged.

For a brief description of the history of water use in the Sacramento-San Joaquin River and Delta system and an explanation of how CVP/SWP export and other uses have strained native fish and their habitat, see Ellen Hanak, Jay Lund, Ariel Dinar, Brian Gray, Richard Howitt, Jeffrey Mount, Peter Moyle & Barton Thompson Managing California's Water: From Conflict to Reconciliation (Public Policy Institute of California 2011), Chapter One. For an overview of the BDCP, see Bay Delta Conservation Plan: Executive Summary (2013).

questions about the Plan. This report provides answers to these questions, along with limited recommendations on how to improve BDCP.

To simplify analysis, this review focuses on conditions for federally listed fishes during the Early Long Term ("ELT"), a decade after a permit would be issued (approximately year 2025). These are described in detail in the BDCP Effects Analysis and accompanying Environmental Impact Statement/Environmental Impact Report. We compared the performance of three different scenarios: a No Action Alternative ("NAA") where no new North Delta diversion facility is constructed, a High Outflow Scenario ("HOS") where the facilities are operated in a way that allows for occasional high spring and fall outflows, and a Low Outflow Scenario ("LOS") with lower spring and fall outflows. The review also emphasizes in-Delta and Sacramento River watershed conditions during the ELT, with less attention to San Joaquin River conditions and fishes.

Although multiple data sources were used in this analysis, most hydrologic data came from CALSIM simulations conducted by BDCP consultants. The Panel strongly cautions about the conclusions drawn from these simulations. Flow simulations have three compounding uncertainties that can lead to significant error: (1) uncertainty in system understanding and future conditions; (2) model uncertainties (particularly the relationships between 1-, 2-, and 3-dimensional models); and, (3) behavioral/regulatory uncertainty where the models cannot capture the scope of human behavior in operating the projects under various conditions. These uncertainties, which are not described in BDCP documents well, makes all of our conclusions contingent on the projects *actually being operated as simulated*.

Do Operations Shift Delta Exports from Dry to Wet Years?

The BDCP calls for increasing exports in wet years and reducing them in dry years, taking advantage of the increased operational flexibility provided by two points of diversion. This would reduce stress on Delta ecosystems during drier periods. Our analysis of simulation data suggests that while there is some increase in flexibility, export operations are highly constrained by upstream consumptive uses, regulations that cover reservoir operations, and flow and water quality standards. This greatly limits the anticipated benefit associated with operation of the dual facilities. Despite these limitations, as modeled, there is an increase in exports in wet years. In most dry years there are no substantial changes over NAA conditions. However, significant improvements in outflow and Old and Middle River ("OMR") conditions occur in some dry years. We were unable to identify the regulatory or operational requirements that would lead to this.

Are Impacts of the North Delta Facility Fully Assessed and Mitigated?

The Plan identifies multiple near- and far-field effects of the new North Delta facility. Based on our review of the Effects Analysis, the Plan appears to have properly identified the most significant effects and uses standard models to assess them. Outmigrating juvenile winter-run and spring-run Chinook salmon will be most heavily affected, leading, in the absence of mitigation, to significant losses. The Plan identifies multiple mitigation strategies, including pulse flow management, predator control, entrainment reduction, non-physical barriers, real-time operations and development of alternative migration pathways (Yolo Bypass). With the exception of benefits from diverting juveniles onto the Yolo Bypass, all of these mitigation approaches have high uncertainties. Done well and successfully, however, they appear to offset the losses associated with operation of the North Delta facility. The HOS appears most protective of conditions upstream of the Delta and adjacent to the new facility. However, mitigation actions are unlikely to contribute significantly to recovery of these species. Additionally, successful mitigation is likely to occur only if there is a robust adaptive management and real-time operations program. The Plan provides neither.

Are In-Delta Conditions Significantly Improved for Smelt?

We evaluated the modeling results in the Plan and conducted our own modeling to evaluate how changes in conditions would affect delta and longfin smelt. As noted, we are concerned that anomalously positive (or less negative) OMR flows and high Delta outflows that are modeled during some drier years would not actually occur in real operations. However, if these changes were to occur we find modest to significant improvement in in-Delta conditions for smelt, particularly delta smelt. Improvements in OMR flows under HOS and LOS result in substantial decreases in entrainment, leading to significant increases in long-term survival percentages for delta smelt. However, increases in spring and fall outflow under HOS lead to small increases in longfin smelt abundance and modest improvements in delta smelt recruitment.

Will Pelagic Fishes Benefit from Floodplain and Tidal Marsh Restoration?

The Plan properly identifies food limitation as a significant stressor on smelt populations in the Delta. The Plan proposes to address this issue by restoring physical habitat to help subsidize pelagic food webs. Based on simple modeling and comparison with other systems, we find that restored floodplains and tidal marshes are unlikely to make a significant contribution to smelt rearing habitat conditions. Tidal marshes can be sinks or sources of food, with most appearing to be sinks for zooplankton. The Plan appears to be too optimistic about the benefits of tidal marsh and floodplain restoration. However, there is likely to be benefit where fishes have direct access to productivity, such as in Cache Slough. In addition, although benefits for listed pelagic fishes are low, there are broad benefits of restoration for many aquatic and terrestrial species covered by the Plan.

Does the Plan Provide an Effective Governance Structure?

We reviewed the proposed BDCP governance structure to evaluate its likely effectiveness in meeting the Plan's goals and objectives. Implementation of BDCP would be overseen by an Authorized Entity Group (AEG) comprising the California Department of Water Resources (DWR), the U.S. Bureau of Reclamation (USBR), and the state and federal water contractors if they are issued incidental take permits pursuant to the BDCP. A Permit Oversight Group (POG), consisting of the U.S. Fish and Wildlife Service (USFS), the National Marine Fisheries Service (NMFS), and the California Department of Fish and Wildlife (CDFW), would monitor implementation of the Plan and compliance with the biological objectives and conservation requirements. The draft BDCP includes a 50-year "no surprises" guarantee, as well as other regulatory assurances. We found that, when examined in detail, the draft BDCP blurs the lines between implementation and regulation and grants the permittees unusual decision authority. Additionally, the regulatory assurances in the Plan, especially the "no-surprises" policy, place undue financial responsibilities on the state and federal governments if certain modifications to the Plan become necessary during its 50-year term. Given the complexity of the Delta ecosystem, predicted changes in hydrology, anticipated changes in the Delta not included in the Plan, and significant scientific uncertainties, Plan modifications are likely to be needed in the future.

Is There a Robust Science and Adaptive Management Plan for BDCP?

The Plan is committed to adaptive management in order to address the high uncertainties. Most of the unresolved issues in the Plan are to be resolved at a future date through adaptive management. A "decision tree" approach is proposed to resolve conflicts over starting operations. We found that the governance structure, whereby the AEG may exercise veto authority over changes to the biological objectives and conservation measures, is likely to create disincentives for adaptive management. In addition, a proposed consensus-based Adaptive Management Team made up of POG, AEG, and scientific community members creates conflicting relationships between decision-makers and providers of key information. The limited information available about the science program suggests that BDCP proposes to develop a wholly new science program that is not integrated, but should be, with existing programs. Finally, our review of the "decision tree" process indicates that it is unlikely to achieve the goal of significantly reducing uncertainties before the North Delta facility is constructed and ready for operation.

Recommendations

Based on answers to these six questions, the Panel formulated a list of nine recommendations for improving BDCP.

- All parties need to recognize the model uncertainties in BDCP and factor that into decision-making. It is unlikely that actual operations will follow simulated operations.
- Given the high uncertainty over mitigation for the North Delta facility, all mitigation efforts should be in-place and tested before the facility is completed. This includes completion of the Fremont Weir modifications on the Yolo Bypass as well as large scale, significant experiments in real-time flow management, predator control and non-physical barriers.
- The improvements in long-term survival percentages for delta smelt in response to changes in OMR need to be more rigorously evaluated, particularly in light of uncertainties over operations. If further examination supports these findings, operational rules should be developed that insure that the anomalous, significantly improved drier-period OMR and outflow conditions occur.
- The limited benefit derived from changes in outflow under HOS requires a second look at options for significant increases in outflow, including finding sources of water outside the direct control of BDCP.
- Although we find that marsh and floodplain restoration is unlikely to create the benefits for pelagic fishes described in the Plan, this can only be resolved through experimental restoration projects. These projects need to be designed and implemented rapidly to resolve this issue.
- Substantial revision of BDCP's governance structure is needed. This includes giving full regulatory authority to the POG, while limiting their involvement in implementation.
- To address high uncertainties about project performance and future conditions, instead of a 50-year permit, there should be renewable "no surprises" guarantees issued every ten years based on conditions at the time and prior performance.
- An adaptive management program needs to be developed that has the capacity and authority to conduct adaptive management experiments and effectively use outcomes to revise and improve future actions.
- A well-funded BDCP science program needs to be developed that is integrated with existing Delta science programs. The best opportunity for integration lies with the current efforts to update the Delta Science Program.

Chapter 1: The Bay Delta Conservation Plan and Charge to the Panel

A. Introduction

The Bay Delta Conservation Plan (BDCP) is being developed to meet endangered species act permit requirements for operations of the Federal Central Valley Project (CVP) and the State Water Project (SWP) within the Sacramento-San Joaquin Delta. The Plan includes proposals for new points of diversion in the North Delta, new operations criteria, extensive floodplain and tidal marsh restoration, and new governance, oversight and adaptive management programs. The Plan applicants are seeking Habitat Conservation Plan (HCP)/Natural Communities Conservation Plan (NCCP) permits that will guide water exports and habitat management for 50 years.

The Bay Delta Conservation Plan is the most complex HCP/NCCP permit application ever attempted. Development of the Plan has been funded principally by state and federal water contractors and has been on-going for more than five years. In Spring 2013, select chapters of the Administrative Draft of BDCP were serially released for public review.[2] An Administrative Draft of the EIS/EIR for the Plan was released in May 2013.[3]

At the request of The Nature Conservancy California and American Rivers—two nongovernmental organizations engaged in the BDCP process—an independent panel of five experts (Text Box 1.1) was assembled to assist in technical review of BDCP documents. The panel was asked to answer a suite of questions about the Plan to help inform decisionmaking by American Rivers and The Nature Conservancy. The panel was assembled and managed by Saracino & Mount, LLC, under contract from the S. D. Bechtel, Jr. Foundation Water Program. NewFields, Inc. provided support for the panel, including data retrieval, analysis and presentation. This report summarizes the conclusions of the work of this panel.

2. This report assumes that the reader is familiar with the Sacramento-San Joaquin Delta and on-going efforts to manage water supply and ecosystems to meet the co-equal goals prescribed in the 2009 Delta Reform Act. A summary of conditions in the Delta and other issues can be found at: http://baydeltaconservation plan.com/Home.aspx.

3. *Available at* http://baydeltaconservationplan.com/Library/DocumentsLanding Page/EIREISDocuments.aspx.

Text Box 1.1: Members of the Review Panel

Jeffrey Mount, Ph.D. (chair) geomorphologist, Professor Emeritus UC Davis, former Chair of the Delta Independent Science Board, and Partner, Saracino & Mount, LLC

William Fleenor, Ph.D. hydrologist and water quality specialist, Research Scientist, UC Davis Center for Watershed Sciences

Brian Gray, J.D. Professor of Law, UC Hastings

Bruce Herbold, Ph.D. *retired* US Environmental Protection Agency, former Coordinator for the Interagency Ecological Program

Wim Kimmerer, Ph.D. food web ecologist, Researcher, San Francisco State University, Tiburon Center

B. Guiding Questions

Two planning meetings were held between Saracino & Mount, LLC and staff of American Rivers and The Nature Conservancy. An initial list of more than 40 questions were developed that were germane to decisions that the organizations needed to make about future engagement with BDCP. These questions were distilled into the following six:

- Q.1 Do operations of the dual facilities meet the broader goal of taking advantage of wet and above average years for exports while reducing pressure on below average, dry and critically dry years? What substantive changes in operations (and responses, see below) are there both seasonally and interannually?
- Q.2 Based on operations criteria, does the Plan properly identify ecological impacts likely to occur adjacent to and in the bypass reach downstream of the new North Delta diversion facilities? If there will be direct and indirect harm to listed species by the facilities, does the Plan prescribe sufficient mitigation measures?
- Q.3 Are changes in operations and points of diversion prescribed in the Plan sufficient to significantly improve in-Delta conditions for covered species? The focus is on listed species, including delta and longfin smelt, steelhead, winter and spring run Chinook, and green sturgeon.
- Q.4 Are covered pelagic fish like longfin smelt and delta smelt likely to benefit from restoration of floodplain and tidal marsh habitat at the scale proposed by the Plan? Given the current state of knowledge, and assuming that all Plan commitments are met, are these efforts likely to result in relaxed X2 and spring outflow standards?
- Q.5 Does the Plan provide achievable, clear and measureable goals and objectives, as well as governance that is transparent and resilient to political and special interest influence?
- Q.6 Is there a robust science and adaptive management plan for BDCP? As described, is the proposed "decision tree" likely to resolve major issues regarding Fall X2 and Spring Outflow prior to initial operations?

Using these questions as guide, the panel reviewed selected chapters within the Plan. The focus of the review was on the biological goals and objectives for species of fish listed as threatened or endangered (BDCP Chapters 1, 2), the conservation measures proposed to meet the biological objectives (BDCP Chapter 3 and appendixes, see Text Box 1.2), and the analysis of the effects of the project on Delta fish species and communities (BDCP Chapter 5 and appendixes). The panel also examined governance, adaptive management and science programs proposed in the Plan, including the "decision tree" intended to resolve technical disagreements about initial operations (BDCP Chapters 3, 5, 6, 7, 8, 9, 10).

In addition to reviewing BDCP documents and literature, the panel held two meetings with the consultants who prepared the Plan for the project applicants. The consultants answered questions about analyses contained within the Plan and provided or directed panel members to pertinent sources of modeling data.

Text Box 1.2: Conservation Measures Considered by the Panel

There are 22 different conservation measures in BDCP. Since the questions asked were narrowly defined, the Panel focused only on five of the measures. These include:

Conservation Measure 1: Operations and Facilities.
This covers the design, implementation and operation of a new North Delta point of diversion and the operation of all SWP and CVP facilities to improve conditions for listed species.

Conservation Measure 2: Yolo Bypass Fisheries Enhancement.
The Plan proposes to increase winter flooding in the Yolo Bypass to improve rearing habitat for salmon as well as improve Delta food webs.

Conservation Measure 4: Tidal Natural Communities Restoration.
This measure seeks to restore 55,000 acres of tidal freshwater and brackish marsh, with an additional 10,000 acres of transitional habitat. This will improve rearing habitat for several listed species and improve food webs for pelagic fishes.

Conservation Measure 5: Seasonally Inundated Floodplain Restoration. The Plan seeks to restore 10,000 acres of seasonal floodplain outside of the Yolo Bypass. This supports juvenile salmonids and overall food web productivity of the Delta.

Conservation Measure 6: Channel Margin Enhancement.
The goal of the Plan is to improve conditions for rearing salmonids along channels of the Delta with close levees. This measure will improve 20 linear miles of channel by creating mudflat, riparian and wetland habitat through levee setbacks.

C. Basis of Comparison

The Bay Delta Conservation Plan seeks a permit for operation of the SWP and CVP at a future date when new facilities will be constructed. As written, the preferred alternative is to construct a new point of diversion in the North Delta on the Sacramento River near Freeport, with the goal of completion in 2025. This diversion is to have three screened intakes that will divert water into forebays and a pair of tunnels capable of transmitting a maximum of 9000 cfs by gravity feed. These tunnels will link to existing SWP and CVP export facilities located in the South Delta. Permit authority for the construction and combined operations of these facilities—typically referred to as dual facilities—are the foundation of the plan. Construction and operations are paired with extensive conservation measures (see below) to mitigate for impacts of the project and to conserve and recover listed species and their biological communities.

One of the many controversies surrounding the Plan is the establishment of an environmental baseline for comparison of alternatives and analysis of the effects of the project on listed species. The requirements of the Biological Opinions (BiOps) issued by the U.S. Fish and Wildlife Service (USFWS) in 2008 and the National Marine Fisheries Service (NMFS) in 2009 constitute the baseline for the Plan. There is considerable debate between the fish agencies (NMFS and USFWS principally) and the permittees over the provisions of these BiOps, particularly in regard to requirements for high Delta outflows to support longfin smelt in the spring and high outflows to achieve Fall X2 (low-salinity zone) provisions to support delta smelt. For this reason, there are two Existing Biological Conditions (EBC) considered by the Plan (Table 1.1): EBC1 includes high spring outflow provisions and EBC2, includes both high spring outflow and the new Fall X2 provisions.

A central requirement of the Plan, and the source of much of its complexity, is to analyze conditions over the 50-year life of the project. The Plan divides future conditions into two classes: Early Long Term (ELT), which captures the initial operating conditions of the project once a new diversion facility has been constructed (approximately 2025), and Late Long Term (LLT) which accounts for full completion of all conservation measures, including restoration of more than 55,000 acres of tidal marsh and floodplain (approximately 2060). Climate changes, particularly changes in runoff and sea level, and changes in water demand are incorporated in these projections.

The controversy over spring and fall outflow needs for conservation and recovery of listed species propagates into the assessments of future conditions. Without-project EBC1 and EBC2 are considered for both ELT and LLT. Evaluated starting operations (ESO) of the preferred project and alternatives are presented for ELT and LLT conditions. Two additional future scenarios are evaluated that purport to provide bookends to project operations that dictate future water exports. The first is a High Outflow

Scenario (HOS), which is similar to the outflow standards in EBC2 (high spring and fall outflow). The second is a Low Outflow Scenario (LOS), which has reduced outflow standards for both spring and fall. Both the LOS and HOS are considered in the ELT and LLT, with the latter including completion of habitat restoration. The Plan proposes a "decision tree process" be undertaken during construction of the facility that will reduce uncertainties and guide initial project operations, presumably within the bounds of the HOS and LOS (reviewed in Chapter 9).

For the purposes of this review, we simplified our comparison of operations and restoration scenarios to just three. Using simulation data provided by BDCP consultants we examined the HOS and LOS scenarios for ELT. We then used a no-project alternative, NAA ELT, which commonly appears throughout BDCP documentation, particularly in the EIR/EIS. NAA prescribes a high fall outflow to maintain X2 standards for smelt and D-1641 salinity and flow standards required by the State Water Resources Control Board for the remainder of the year.

Table 1.1. Definitions of Existing Baseline Conditions and Project Conditions Simulated in BDCP

Conditions		Description
Existing Biological Conditions	EBC1	Current operations based on BiOps, excluding management of outflows to the Fall X2 provisions of USFWS 2008 BiOp.
	EBC2	Current operations based on BiOps, including management of outflows to meet USFWS Fall X2 provisions from 2008 BiOp.
Projected Future Conditions without the BDCP	EBC2_ELT	EBC2 projected into year 15 (2025) accounting for climate change expected at that time.
	EBC2_LLT	EBC2 projected into year 50 (2060) accounting for climate change expected at that time.
Projected Future Conditions with the BDCP	ESO_ELT	Evaluated starting operations in year 15 assuming new intake facility operational and restoration not fully implemented.
	ESO_LLT	Evaluated starting operations in year 50 assuming new intake facility operational and restoration fully implemented.
	HOS_ELT	High-outflow operations during spring and fall in year 15 assuming new intake facility operational and restoration not fully implemented.
	HOS_LLT	High-outflow operations during spring and fall in year 50 assuming new intake facility

		operational and restoration fully implemented.
	LOS_ELT	Low-outflow operations during spring and fall in year 15 assuming new intake facility operational and restoration not fully implemented.
	LOS_LLT	Low-outflow operations during spring and fall in year 50 assuming new intake facility operational and restoration fully implemented.

It should be noted that the Panel chose not to review LLT scenarios and conditions beyond the question of whether restoration of marsh is likely to benefit listed fishes. Although it is necessary and useful to consider how the project might operate over the long-term, especially under climate change, the Panel felt that exceptionally high uncertainties made it difficult to offer precise answers within the LLT framework. These uncertainties are associated with our understanding of the Delta, with the models used to simulate future conditions, and with the array of events (biological invasions, floods, droughts, earthquakes, policy changes, lawsuits, etc.) that are likely to occur.

D. A Note About Hydrologic Modeling Tools and Uncertainties

The basis for the BDCP analysis is hydrologic simulation modeling that provides flow, water elevations, temperature and salinity at various locations throughout the Delta and its upstream areas. Much of the Effects Analysis for aquatic species and all of the export projections are based on outputs from these hydrologic models. BDCP is one of the most complex modeling efforts of its kind and certainly the most complex ever attempted in the Delta. This is a heroic modeling effort.

There are three general categories of uncertainty in the hydrologic model results:

Model uncertainties. This includes how the model simulates hydrology and the hydrologic results of operations, including salinity, temperatures and other water quality parameters. The currently available modeling tools are less than ideal to simulate such a long-term record with dramatic changes in conditions such as sea level rise and introduced sub-tidal and inter-tidal land. The principal issues are summarized in Text Box 1.3.

Future condition uncertainties. There is extensive effort in BDCP to estimate future conditions in the Delta, including sea level rise and changes in temperature and runoff. This is the most comprehensive approach to date. These are described well in Appendix 5A of the Plan and highlight high levels of uncertainty.

Regulatory and behavioral uncertainty. BDCP models assume that flow and water quality standards will remain static during the life of the project. In addition, the models assume uniform behavior of system operators, ignoring real-time operations and adaptations. All of these are highly unlikely to occur.

The hydrologic model results of BDCP are presented as if they are a unique solution. Given the compounding uncertainties, BDCP model results should be considered as scenarios rather than specific outcomes. This issue is often lost in the public debates over BDCP. As discussed later in this report, the model uncertainties significantly impact our confidence in some of our results, particularly our analysis of the response of pelagic fishes to changes in South Delta operations.

Text Box 1.3: Hydrologic Model Uncertainty

To adapt existing tools to model future conditions under BDCP consultants developed dispersion coefficients with the 3-dimensional UnTRIM model developed by Michael MacWilliams for sea level rise. A similar process was then followed with a 2-dimensional model developed by Research Management Associates to estimate the additional dispersion for the proposed new open tidal areas. Parameters developed from the multi-dimensional efforts were then incorporated into the 1-dimensional DSM2 planning model developed by DWR to simulate a part of the long-term record incorporating sea level rise and tidally restored acreage. The boundary conditions for the DSM2 model, which operates at time steps as short as 15 minutes, was provided by CALSIM, the 1-dimensional system-wide water operations optimization model. CALSIM output occurs on monthly time steps and had to be disaggregated to provide boundary conditions for DSM2. All the results, including the DSM2 results and artificial neural network salinity results, were then used to train the CALSIM model. The CALSIM model was then used to simulate the entire 82-year record that formed the basis for the Effects Analysis. All of these model exchanges, particularly between 1-, 2-, and 3-dimentional models, create error or model bias. To date, there is no assessment of these model biases and how they impact BDCP results.

E. Organization of This Report

This report is organized into ten chapters followed by a summary of answers to the guiding questions. Chapters 2-10 include:

- *Chapter 2, Overview of the Law Governing* BDCP. Although not specifically requested by TNC and AR, we found it helpful to review key provisions of the HCP/NCCP laws that set standards for recovery of populations of covered fishes.

- *Chapter 3, Water Supply Operations*. This chapter examines how BDCP performs in meeting the goal of increasing water supply reliability. This includes assessment of changes in export volumes, both seasonally and within different year types.
- *Chapter 4, Environmental Flow Performance: Upstream and Inflows*. The new facilities and their operation are supposed to improve flow conditions impacted by the SWP and CVP. This chapter describes flows regulated by project dams, flows past and through the new North Delta facilities, and the overall inflow regime of the estuary.
- *Chapter 5, In-Delta Effects on Pelagic Fishes*. The changes in flow conditions outlined in the previous chapter translate to changes in ecological conditions for listed fish species. This chapter evaluates the likely response of delta smelt and longfin smelt to these changes
- *Chapter 6, Estimated Effects of* BDCP *Flows on Smelt*. This chapter examines the magnitude of changes in outflow and the likely response of delta and longfin smelt.
- *Chapter 7, Likely Response of Listed Fishes to Habitat Restoration*. A fundamental hypothesis of BDCP is that restoration of physical habitat, particularly tidal marsh, will improve food web conditions for pelagic fishes, aiding their recovery. This chapter evaluates this hypothesis.
- *Chapter 8, Governance and Terms of* BDCP. The 50-year permit for the project, coupled with governance and oversight, are examined in this chapter.
- *Chapter 9, Science and Adaptive Management*. The Plan makes extensive mention of the use of adaptive management supported by robust science to address major uncertainties. The Plan's objectives in this regard are reviewed.

  Chapter 10, Summary and Conclusions. This chapter provides a summary of answers to the six questions presented to the panel by American Rivers and The Nature Conservancy. In addition, where appropriate, recommendations are offered for ways to improve the performance of BDCP.

F. Conclusion

This report is, by design, narrowly focused on a limited set of issues of concern to The Nature Conservancy and American Rivers. It is not intended to serve as a broad review of BDCP, nor is it directed toward a wide audience. In addition, the panel specifically steered away from endorsing or rejecting BDCP, and makes no recommendation on the critical question of whether American Rivers and The Nature Conservancy should support BDCP, support it with modifications, or reject/oppose it. Rather, the observations, analyses and recommendations are solely intended to inform this decision.

Chapter 2: An Overview of the Law Governing the BDCP

A. Introduction

This chapter provides a brief overview of the law that governs the creation and implementation of the Bay Delta Conservation Plan. It also addresses an important question that has arisen during the BDCP negotiations: May the Director of the California Department of Fish and Wildlife (CDFW) approve the BDCP as a natural community conservation plan if the BDCP does not provide for full recovery of the endangered and threatened species covered by the Plan?

B. Habitat Conservation Planning and Natural Community Conservation Planning Under Federal and California Law

The BDCP is a Habitat Conservation Plan (HCP) authorized by section 10(a) of the federal Endangered Species Act (ESA),[4] and a Natural Community Conservation Plan (NCCP) authorized by the California Natural Community Conservation Planning Act (NCCPA).[5] Section 10(a) of the federal ESA allows the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to issue permits that authorize the taking of endangered or threatened species "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" and the proposed activity is governed by an approved HCP.[6] Similarly, under the NCCPA the California Department of Fish and Wildlife (CDFW) may "authorize by permit the taking of any covered species . . . whose conservation and management is provided for in a natural community conservation plan approved by the department."[7]

If approved by the three fish and wildlife agencies, the BDCP will be a legally binding document that defines the terms and conditions under which the U.S. Bureau of Reclamation (USBR) and the California Department of Water Resources (DWR) may construct and operate the proposed new water diversion and transport facilities described in the draft Plan.[8] The BDCP also

4. 16 U.S.C. § 1539(a) (2013).

5. CAL. FISH & GAME CODE §§ 2800-2835 (2013).

6. 16 U.S.C. § 1539(a) (2013).

7. CAL. FISH & GAME CODE § 2835 (2013). The NCCPA defines "covered species" to include species that are listed for protection under the California Endangered Species Act, CAL. FISH & GAME CODE §§ 2050-2115.5, and nonlisted species that are "conserved and managed under [another] approved natural community conservation plan and that may be authorized for take." *Id.* at § 2805(e).

8. The statutory requirements for the contents and approval of the BDCP as an HCP and NCCP are set forth respectively in section 10(a)(2)(A) & (B) of the federal

will serve as "a comprehensive conservation strategy for the Sacramento–San Joaquin River Delta (Delta) designed to restore and protect ecosystem health, water supply, and water quality within a stable regulatory framework."[9]

The BDCP will include "regulatory assurances" that protect the permittees from the financial cost of changes to the BDCP or other regulatory changes needed to protect the species or their habitat. As authorized by federal and state law, these regulatory assurances provide that, if changed circumstances arise that are either unforeseen or not provided for in the Plan, then the fish and wildlife agencies will not require the permittees to devote additional land, water, or financial resources beyond the levels set forth in the BDCP without the consent of the plan participants. Nor will the federal and state regulators impose additional restrictions on project operations without compensating the permittees for the lost water or additional costs.[10]

Both statutes also authorize the fish and wildlife agencies to suspend or revoke the incidental take permits for noncompliance with the terms and conditions of the BDCP or where implementation of the Plan will place the covered species in jeopardy of extinction.[11]

We consider the regulatory assurances, revocation authority, and other aspects of BDCP governance in Chapter 8.

C. Conservation and Recovery Requirements Under Federal and State Law

The federal Endangered Species Act and the California Natural Communities Conservation Planning Act differ in their respective conservation and recovery standards. The federal statute provides that the fish and wildlife agencies may not approve the BDCP unless they determine that the incidental take authorized by the permit and HCP "will not appreciably reduce the likelihood of the survival and recovery of the species in the wild."[12]

Endangered Species Act, 16 U.S.C. § 1539(a)(2)(A) & (B), and sections 2810 and 2820 of the California Fish and Game Code.

9. DRAFT BDCP, at 1-1.

10. The USFWS and NMFS adopted the federal "no surprises" policy by rulemaking in 1998. The substantive requirements of these rules may be found at 50 C.F.R. § 17.22(b)(5) & (6) and 50 C.F.R. § 222.307(g), respectively. The state "no surprises" guarantees are set forth in the NCCPA itself. CAL. FISH & GAME CODE § 2820(f) (2013).

11. The federal suspension and revocation rules are set forth in the Endangered Species Act, 16 U.S.C. § 1539(a)(2)(C), and in the ESA regulations, 50 C.F.R. § 17.22(b)(8). The state law counterparts may be found in CAL. FISH & GAME CODE § 2820(b)(3).

12. 16 U.S.C. § 1539(a)(2)(B)(iv) (2013).

In contrast, the NCCPA states that Department of Fish and Wildlife may approve the BDCP only if it finds *inter alia* that the Plan

> provides for the protection of habitat, natural communities, and species diversity on a landscape or ecosystem level through the creation and long-term management of habitat reserves or other measures that provide equivalent *conservation* of covered species appropriate for land, aquatic, and marine habitats within the plan area.[13]

The Act defines "conservation" as "the use of methods and procedures within the plan area that are necessary *to bring any covered species to the point at which the measures provided pursuant to [the* California Endangered Species Act*] are not necessary*."[14]

In other words, the federal Endangered Species Act requires only that habitat conservation plans ensure that the permitted activities do no significant harm to the listed species or to their critical habitats. The California Natural Communities Conservation Planning Act, by comparison, regards proposed projects such as the BDCP as opportunities for more coordinated and cohesive planning to improve the condition of covered species and their habitat, rather than simply being a means to authorize the permitted activities while maintaining the *status quo ante*.

The draft BDCP describes its biological goals and objectives in two different ways. At the "landscape level," the goals include restoration or creation of "ecological processes and conditions that sustain and reestablish natural communities and native species."[15] At the "species level," however, the biological goals refer to *progress toward* the landscape level goal of reestablished and sustainable natural communities and native species.

Thus, the primary biological goals for the Delta Smelt and Longfin Smelt are "increased end of year fecundity and improved survival of adult and juvenile . . . smelt to support increase abundance and long-term population viability."[16] Similarly, the principal biological goal for Sacramento Winter-Run Chinook Salmon is "improved survival (to contribute to increased abundance) of immigrating and emigrating . . . salmon through the Plan Area,"[17] and for other species of salmon and steelhead the goal is "increased . . . abundance."[18]

13. CAL. FISH & GAME CODE § 2820(a)(3) (2013) (emphasis added).
14. CAL. FISH & GAME CODE § 2805(d) (2013) (emphasis added).
15. DRAFT BDCP, at 3.3-5.
16. *Id.* at 3.3-13, 3.3-16.
17. *Id.* at 3.3-16.
18. *Id.* at 3.3-17 to 3.3-19.

The draft BDCP explains that the process of developing these species level biological goals "did not assume that the BDCP would be solely responsible for recovery of these species, and so the designated biological goals and objectives did not necessarily match the recovery goals, but instead represented the BDCP's potential to *contribute to recovery* within the Plan Area.[19] This decision has become a focal point of debate over the essential purposes and mandates of the NCCPA.

In a July 10, 2013, letter to the Director of CDFW, three environmental organizations challenged the BDCP's proposed adoption of biological goals that do not provide for full recovery of the species, arguing that this "contribution to recovery" standard violates California law:

> Under the plain text of the NCCPA, conservation means recovery, and a Plan is required to contain measures that are sufficient to achieve recovery within the plan area.[20]

As described in detail in the chapters that follow, the limitations on project operations and other conservation measures set forth in the draft BDCP would not meet the conservation standard proposed by the July 10th letter—viz. full recovery of the listed species—though they are likely to contribute to species recovery. The letter thus raises a critical legal question that will have to be resolved by the Director of CDFW, in consultation with the Department's General Counsel and the Attorney General, before the Department decides whether to approve the BDCP.

The answer to this question is not free from doubt, as the Legislature defined the purposes of the NCCPA in terms that stand in some tension to one another. For example, section 2801(i) declares that the "purpose of natural community conservation planning is to *sustain and restore* those species and their habitat . . . that are necessary to maintain the continued viability of those biological communities impacted by human changes to the landscape."[21] In contrast, section 2801(g) states that "[n]atural community conservation planning is a mechanism that can provide an early planning framework for proposed development projects . . . in order to avoid, minimize, and compensate *for project impacts to wildlife*."[22]

19. *Id.* at 3.A-14 (emphasis added).

20. Letter to Charlton H. Bonham, Director of the California Department of Fish and Wildlife, from the Defenders of Wildlife, Natural Resources Defense Council, and the Bay Institute, *The Natural Community Conservation Planning Act is the Foundation for a Successful Bay Delta Conservation Plan*, at 5 (July 10, 2013) (citing Fish & Game Code § 2805(c)) (hereinafter "Letter to Director Bonham").

21. CAL. FISH & GAME CODE § 2801(i) (2013) (emphasis added).

22. CAL. FISH & GAME CODE § 2801(g) (2013) (emphasis added).

A careful and integrated reading of the text of the substantive provisions of the statute, however, should lead to the conclusion that the Act authorizes the CDFW to approve the BDCP if it concludes that the Plan would protect listed species from the adverse effects of the projects authorized by the Plan (including full mitigation of those effects) *and* would promote the recovery of listed species. Stated differently, we do not believe that the Legislature intended to prohibit the Department from approving the BDCP unless it concludes that the Plan—in isolation both from other existing sources of the species' decline and from other state and federal actions to protect listed species—will achieve full recovery of the species. We reach this conclusion for several reasons.

First, the interpretation of the statute proposed in the July 10th letter is based entirely on the section of the Act that defines the term "conservation." If the Legislature actually intended to require the CDFW to determine that an NCCP would be likely to achieve full recovery of listed species, it would have included this requirement in Section 2820, which governs the Department's approval of proposed NCCPs.

Section 2820(a) lists ten separate findings that are prerequisite to CDFW approval, and section 2820(b) contains nine terms that must be included in the implementation agreements that accompany the NCCPs. None of these mandatory findings and terms includes the requirement proposed in the July 10th letter. We do not believe that the Legislature somehow intended to add a twentieth requirement to these lists—that the NCCP and implementation plan must provide for full species recovery—by implication from the definitions section of the Act.

Second, there are two provisions in section 2820 that expressly link the required conservation measures to the effects of the project authorized by an NCCP. Section 2820(a) states that the CDFW may approve an NCCP only if it finds that the plan

> contains specific conservation measures that meet the biological needs of covered species and that are based upon the best available scientific information regarding the status of covered species and the impacts of permitted activities on those species.[23]

Section 2820(b) stipulates that implementation agreements must include provisions

> to ensure that implementation of mitigation and conservation measures on a plan basis is roughly proportional in time and extent to the impact on habitat or covered species authorized

23. CAL. FISH & GAME CODE § 2820(a)(6) (2013) (emphasis added).

> under the plan. These provisions shall identify the conservation measures . . . that will be maintained or carried out in rough proportion to the impact on habitat or covered species.[24]

This pairing of conservation and recovery with references to the "impacts of permitted activities," together with the "rough proportionality" limitation on conservation measures, suggests that the Legislature intended to authorize NCCPs as a means of contributing to other state and federal efforts to recover species, but not significantly in excess of the burdens that the project covered by the plan would impose on the species.[25]

Third, there is nothing in the text or legislative history of the NCCPA to indicate that the Legislature intended to force the state to bear programmatic and financial responsibility for full species recovery each time the CDFW approves an NCCP.[26] Conservation measures required to achieve full recovery may extend far beyond the scope of an individual NCCP. Indeed, a requirement of full recovery would be particularly problematic for plans such as the BDCP that involve multiple species (some of which only partly inhabit the program area), multiple sources of stress, and diverse land and water management and regulatory agencies that each have independent obligations to contribute to species conservation and recovery. We do not believe that the Legislature would have assigned such a Herculean obligation to the Department, or imposed such a potentially large financial burden on state taxpayers, without saying so explicitly in the text of the statute.

24. CAL. FISH & GAME CODE § 2820(b)(9) (2013) (emphasis added).

25. The July 10th letter acknowledges that the NCCPA contains this "rough proportionality" limitation, but argues that "the concept of 'rough proportionality' is applied only to mitigation measures and not to a plan's conservation measures." Letter to Director Bonham, *supra*, note 17, at 7. The text of the Act belies this interpretation, however, as four of the five statutory references expressly apply the "rough proportionality" limitation to the conservation requirements. *See* CAL. FISH & GAME CODE §§ 2805(g)(3)(C), 2820(b)(3)(B), § 2820(b)(9) & § 2820(c) (2013).

26. The July 10th letter recognizes that the entities that receive incidental take permits under the BDCP may not be required to bear all of the costs of recovery of the various listed species: "[W]hen dividing up the costs of the plan's conservation strategy, the individual developers are only responsible for paying for 'mitigation' and the 'conservation' increment above mitigation is the responsibility of the state." Letter to Director Bonham, *supra*, note 17, at 7. Thus, if the costs of recovery exceed the mitigation costs that lawfully may be assigned to the permitted entities, the state must make up the difference: "The BDCP cannot limit its conservation measures to address only those impacts from the covered activities and avoid providing conservation measures sufficient to recover covered species." *Id.* at 8.

Finally, an interpretation of the statute that would require the CDFW to make a determination that all proposed NCCPs provide for full recovery of listed species would likely have the unintended and pernicious consequence of deterring the Department from approving future plans. The CDFW might conclude that the scope of the necessary species recovery effort extends beyond the scope of the proposed project and hence beyond the capabilities of the project restrictions and conservation measures that would be included in the individual NCCP. Or it might be reluctant to approve an NCCP in situations where the costs of full recovery of the listed species covered by the plan—which the state would have to bear—significantly exceed the project mitigation costs that may be placed on the project proponents.

Again, these factors are especially pronounced in contexts such as the Delta ecosystem where there are multiple species (some of whose habitat is only partly within the project area), multiple stressors (many of which are not plan participants), overlapping and sometimes conflicting habitat requirements, and tremendous uncertainty both about the needs of the species and the likelihood of success of recovery strategies. The interpretation of the NCCPA set forth in the July 10th letter therefore poses a significant policy risk of deterring otherwise salutary applications of natural resources conservation planning.

D. Conclusion

We conclude that the draft BDCP's establishment of biological goals and conservation measures that are based on the Plan's "potential to contribute to recovery" of the covered species complies with the Natural Communities Conservation Planning Act. We also believe that the CDFW may approve the Plan if it determines that the BDCP will ensure the survival of the listed species, fully mitigate the adverse effects of the project on all covered species and their habitat, and further the more general state and federal efforts to recover the species and to restore the favorable conditions of their habitat.

Chapter 3: Water Supply Operations

A. Introduction

The construction of a new North Delta diversion facility, and the coordinated operation of the North and South Delta facilities constitute the first and most prominent conservation measure (CM#1) of the BDCP. While ostensibly a conservation measure, the new facilities are principally an effort to improve the reliability of exports from the Delta. Their operations, in conjunction with all other conservation measures, are intended to mitigate for impacts of the CVP and SWP, avoid jeopardy and/or to contribute to the recovery of covered species (Chapter 2).

A basic premise of BDCP is that the construction of the new North Delta diversion facility will simultaneously improve water supply reliability while reducing ecosystem impacts. This stems from the increased operational flexibility associated with two points of diversion located in different portions of the Delta. A presumed benefit of this flexibility is the capacity to take advantage of periods of high inflow for exports, allowing for reductions in exports during dry periods when impacts on the ecosystem may be largest. This is consistent with the co-equal goals expressed in the 2009 Delta Reform Act.

This chapter examines the water supply operations proposed under BDCP to evaluate 1) if there are significant changes in supply reliability associated with the project and 2) how these changes apportion exports in wet versus dry periods. This description is foundational for the assessment of ecological and species-specific consequences of BDCP as described in subsequent chapters.

B. Proposed Facilities and Operations

There are lengthy descriptions of the design and operation of new and existing water export facilities in the Administrative Drafts of the EIR/EIS and BDCP. The reader is referred to these documents for information. The centerpiece of the plan is the 9,000 cfs capacity diversion in the North Delta that conveys water to the SWP and CVP export facilities in the South Delta through two tunnels.

Regulatory Constraints

The operational criteria for the export facilities are both complex and highly constrained (Appendix A). As outlined below, these constraints *significantly reduce the operational flexibility of the facilities*. The current regulatory constraints include but are not limited to:

- SWRCB water rights decision D-1641: this includes standards for minimum monthly Delta outflow, salinity objectives at multiple Delta locations, location of X2 (the position of the 2 ppt salinity near the channel bottom), a maximum export/import ratio objective,[27]

27. BDCP treats the export/import ratio in two ways: 1) counting as "import" all inflows from the San Joaquin and Sacramento Rivers and Delta's tributaries or 2) counting inflows as above, but counting flows below the North Delta facility as inflow. The latter approach seeks to exclude North Delta exports from D-1641 export/import restrictions. From an ecosystem perspective, this makes no sense since the North Delta exports are, in effect, exports from the legal Delta.

closures of the Delta Cross Channel (DCC), placement of a barrier at the head of Old River, and flow standards for the San Joaquin River below Vernalis. These standards vary depending upon months of the year and water year type.

- Remanded 2008 USFWS Biological Opinion (BiOp): prescribes restrictions for magnitude and timing of reverse flows in Old and Middle River (OMR) in the South Delta, to protect delta smelt. These vary depending upon time of year, water temperature, flows on the San Joaquin River, and proximity of smelt. This BiOp also calls for higher spring and fall outflows that exceed D-1641 standards. These outflow standards vary on water year type.
- Remanded 2009 NMFS BiOp: has different restrictions on OMR flows than the USFWS BiOp. Reductions in reverse OMR flows are scheduled to protect outmigrating salmonids. These vary depending on temperature and inflow. This BiOp increased San Joaquin River flows and set export/San Joaquin River flow ratios that are more restrictive than D-1641.

There are other regulatory constraints beyond D-1641 and the two remanded BiOps; however, compliance with these regulations appears to dominate water supply export modeling. Additional constraints are based on proposed operating rules for both the North and South Delta facilities. The most significant include:

- maintenance of minimum flows downstream of the North Delta facility (called "Bypass Flows");
- restrictions aimed to reduce reverse flows at the confluence between the Sacramento River and Georgiana Slough;
- a tiered, three-level pumping regime for December through June that seeks to protect the initial winter flood pulse and spring pulses that affect juvenile salmon outmigration;
- flows with sufficient velocity to reduce impingement of salmonids at diversion screens; and,
  increased restrictions for reverse Old and Middle River (OMR) flows associated with South Delta exports.

Infrastructure and Inflow Constraints

Infrastructure design and capacity forms another array of constraints. For the purposes of BDCP simulation modeling, south of Delta storage was limited to space within San Luis Reservoir. Operations during wet and above average conditions are often constrained by available space to store water in this facility. Expanding potential storage, particularly groundwater storage, would have created considerably more flexibility in exports, particularly during wet years.

The size of the North Delta facility is also a constraint, principally during periods of sustained high flow on the Sacramento River in wet years. The preferred project has shifted from an initial facility size of 15,000 cfs to 9,000 cfs in the current plan. The export, economic and environmental performance of the 9,000 cfs facility is compared to 14 alternatives in Chapter 3 and 5 of the Draft EIS/EIR. These alternatives vary facility size, location and operations in the comparison. A narrative is presented in the EIS/EIR that describes the rationale for rejecting the 14 alternatives and selecting the preferred project.[28]

Exports are also naturally constrained by the timing and volume of inflows, with strong seasonal and interannual variation. One of the larger export challenges faced by BDCP is its location at the bottom of the system where flows enter the Delta. Upstream water management and consumptive use dominate inflows to the Delta over most years (Figure 3.1). These abstractions, which consume roughly ¼ of water that would naturally flow to the Delta, are beyond the control of BDCP, yet are the greatest operational influence on Delta inflows. Under BDCP, exports would be roughly equivalent to upstream consumptive use.

In addition, there are important restrictions on reservoir operations that constrain exports. The USACE has congressionally authorized rule curves that dictate Fall, Winter and Spring operations to maintain flood reserves. More importantly, there are BiOps that dictate flow and temperature requirements to meet the life history needs of covered salmon, steelhead and sturgeon below the dams. Meeting these standards, particularly in drier years and under a warming climate, limits the amount and timing of inflows to the Delta. Oroville Reservoir, which has fewer restrictions on flows, becomes the most important for supporting Delta inflows as a result, particularly during drought conditions (see below).

Consequences of Constraints

The above discussion is intended to highlight a conundrum that is not discussed much outside of the BDCP community of experts and is not examined in the Plan: export operations and operations to support

28. It is beyond the scope of this review to examine facility size in detail. In general, the analyses offered in the EIR/EIS conclude that the 9,000 cfs facility provides the optimal balance of cost and flexibility. The additional capacity of the 15,000 cfs facility is rarely used in the operations that they modeled, leading to a very modest increase (<250 taf) in overall exports. The EIS/EIR did examine smaller facilities with capacities of 6,000 cfs. and 3,000 cfs. However, the operating criteria used to evaluate these two alternatives are not comparable to those of the preferred alternative, making the comparison moot.

conservation are *highly* constrained. These regulatory, operational and infrastructure constraints limit the ability of BDCP to adaptively manage operations to support coequal export *and* ecosystem objectives. For this reason, the anticipated management associated with the new diversion facility is not fully realized.

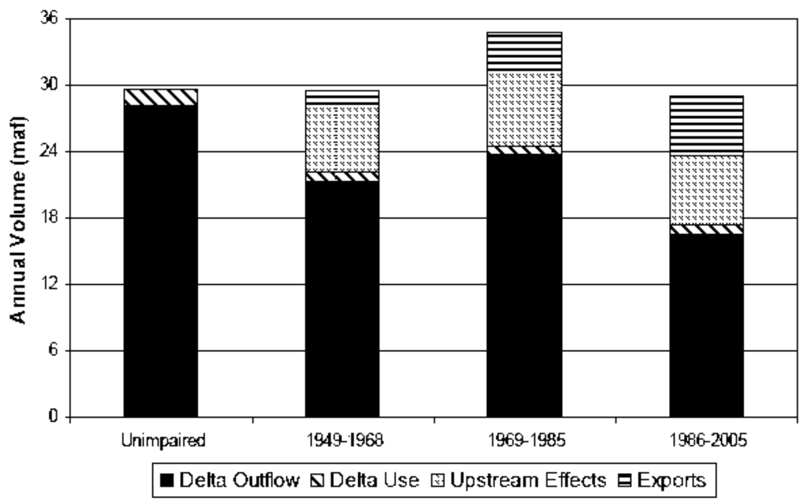


Figure 3.1 Proportional Delta water use. Exports constitute roughly 18% of the total unimpaired flow of the Delta in the 1986-2005 hydrology, with upstream consumptive use approximately 24%.[29]

This also highlights how flow management in BDCP was developed using system models. As described in Appendix 5C of the Plan, the models sought to meet the requirements of D-1641, the remanded BiOps, reservoir and diversion facility constraints, and south of Delta storage. The objective function was then to maximize Delta exports within those constraints. Although this seems logical, it highlights how CM1 is not a conservation measure, per se. Rather than doing a bottom-up assessment of ecosystem flow needs, as is typically done when setting environmental flows, the modeling sought to meet current regulatory requirements and flow constraints sought by fish agencies. This illustrates one of the key points made by Lund et al. (2010) and Moyle et al. (2012) that multi-objective

29. J. LUND, E. HANAK, W. FLEENOR, W. BENNETT, R. HOWITT, J. MOUNT & P. MOYLE, COMPARING FUTURES FOR THE SACRAMENTO-SAN JOAQUIN DELTA. (F. Richard Hauer et al. eds., 2010). [Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

management of the Delta is likely to require a comprehensive re-evaluation of flow and water quality standards.[30]

C. Export Reliability

A goal of the BDCP project and the current Delta Plan is to improve reliability of water derived from the Delta for consumptive uses.[31] Using model simulations provided by BDCP consultants, we have evaluated how well BDCP meets the goal of improving export reliability. The most commonly discussed aspect of BDCP—average annual export—is summarized in Figure 3.2, and compares the no-project alternative, NAA with the high outflow scenario, HOS and low outflow scenario, LOS (defined in Chapter 1). This modeling suggests that the HOS and NAA would provide roughly equal average exports, with the LOS providing approximately 700 taf more. However, these figures are an average over an 82-year simulation period and offer little information about reliability.

30. *Id.*

31. In actuality, the most reliable system would provide a given amount of water each year with the smallest deviation from that amount. Instead, BDCP attempts to produce the most water in any given year under the given regulatory and operational constraints. This produces a more *resilient* water supply systems, whereby the greatest volume is made available, even under the event of catastrophic salinity intrusion into the Delta. The terms resilient and reliable are used interchangeably in BDCP and other documents.

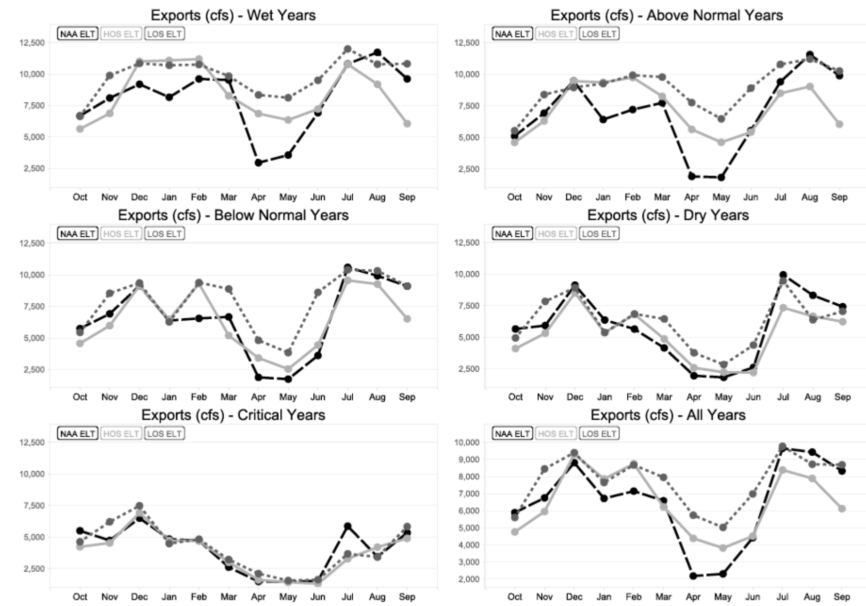


Figure 3.2: Monthly averaged exports for NAA, LOS and HOS under ELT conditions. Based on BDCP CALSIM data.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Exceedance curves (Figure 3.3) give a better indication of reliability. This approach provides the probability that a given export volume will be equaled or exceeded in any given year. For example, for the 50% exceedance probability (meaning one out of every two years), the NAA performs slightly better than the HOS, but much worse than the LOS. Overall, the LOS performs significantly better than NAA in six out of ten years and better than the HOS in eight out of ten. The HOS is outperformed by the NAA in five out of ten years (drier) and appears to only provide significant water supply benefits over the NAA in one out of ten years (wettest). The conclusion is that export reliability for the HOS and NAA are not substantially different, while reliability for the LOS is markedly higher.

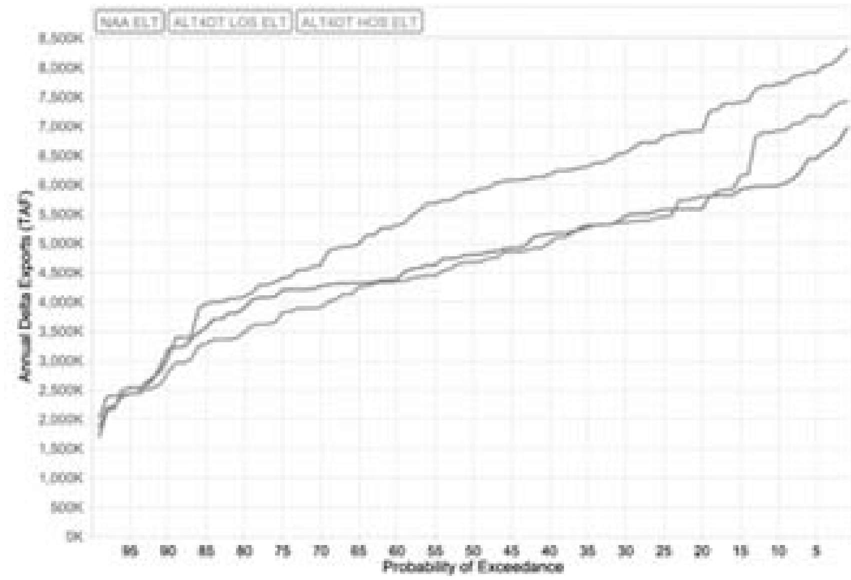


Figure 3.3: Exceedance probabilities for NAA, LOS and HOS exports under ELT conditions. Note that LOS produces higher exports for all probabilities, suggesting that it is the most reliable/resilient of the scenarios.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Water supply reliability curves for SWP and CVP customers are presented in Chapter 5 of the Draft EIS/EIR. These curves indicate that south-of-Delta municipal and farm users would realize considerable increases in overall reliability of supply under the LOS, compared to the NAA and HOS, particularly in above average and wet years. North-of-Delta users of CVP water would likely see a decrease in reliability over the long term, principally due to climate change.

D. Export Timing

A goal of BDCP and the Delta Plan is to shift exports to wetter years and to reduce pressure on drier years. A comparison of the average exports of NAA, LOS and HOS for all five year-types is presented in Figure 3.2. Based on the modeling data provided, there appears to be a significant increase in LOS exports in above average and wet years as compared to the NAA, with HOS intermediate between the two. This increase is accomplished through increased use of the North Delta facility during winter and spring periods when OMR restrictions most strongly impact South Delta operations.

Below average, dry and critical dry year performance of BDCP is mixed (Figure 3.2). For LOS, overall exports during the drier years are higher than the NAA, while HOS exports are roughly the same as NAA. Exports, on average, for both the LOS and HOS tend to be higher than the NAA in the winter and early spring, and lower during the summer. This minimal change in exports during dry years stems, in comparison to wet years, from the constraints on North Delta facility operations. As is illustrated below, during dry periods the North Delta facility is used very little, creating pressure on South Delta facilities.

In sum, although there are many regulatory and infrastructure constraints, BDCP does make use of the dual points of diversion to create modest increases in wet year exports and, depending on which export scenario is evaluated, equal to or greater exports in drier years. BDCP *therefore does not achieve the broader goal of reducing pressure on the Delta during dry years by shifting exports to wet years.*

E. Drought Performance

In the draft Plan and EIR/EIS, export performance of BDCP is summarized by presenting averages, typically linked to water year-types based on the Sacramento 40-30-30 index. Averaging fails to fully reflect how the system might be operated, however, because the complex rules governing operation can create significant year-to-year variability in exports (although see concerns over model uncertainties described in Chapter 1). This issue is particularly acute during multi-year droughts, when carryover storage in reservoirs is greatly reduced and demand increases significantly. To better illustrate how this system might perform we examined time series of model outputs during drought periods.

There were two six-year droughts during the 20th century that fall within the time period used for hydrologic simulations: water years 1929-34 and 1987-92. We focused on the 1987-92 period of record for evaluation because it has historical export data for comparison and facilities that are comparable to today. As shown in Figure 3.4, overall export timing and magnitude during the six-year drought were roughly the same for the NAA, LOS and HOS, with LOS performing marginally better for exports throughout the drought.[32] The significant exception to this pattern is in the

32. Figure 3.4 highlights one of the issues not discussed in BDCP documentation. The environmental baseline for the BDCP assessment was determined to be the remanded BiOps, with provisions of one of the BiOps (high fall X2 flows in above normal and wet years) yet to be enacted. By choosing this as a baseline, the plan does not provide a comparison with how the project was actually operated under historic conditions. This administrative decision to only compare

one year in that sequence, 1989, where modest inflows to the Delta occurred in the winter. Once bypass flow criteria were met, the flexibility created by the North Delta facility was able to take advantage of these inflows during a period of high restrictions on South Delta pumping to protect smelt.

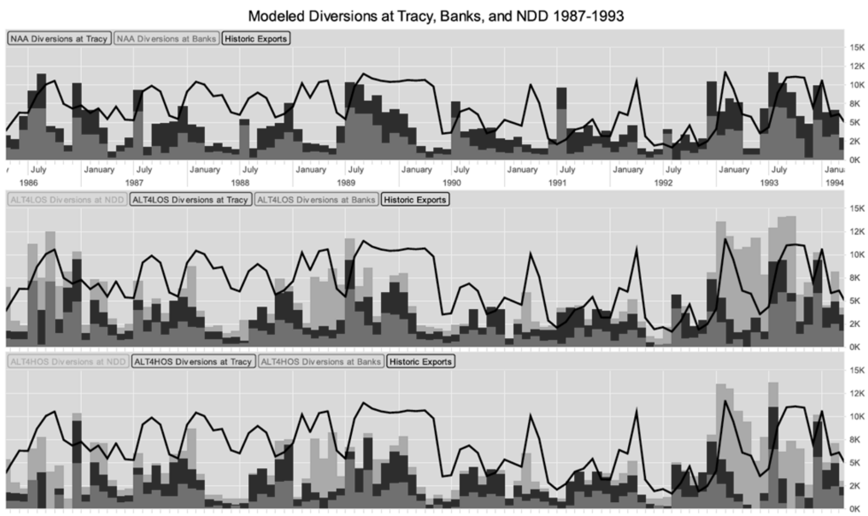


Figure 3.4: Exports for NAA, LOS and HOS under ELT conditions simulated for the 1987-92 drought, with historical exports are plotted for comparison. Important to note that ELT conditions take into account minor changes in climate and sea level rise by 2025 and cannot be compared specifically with historic conditions. In addition, historic conditions reflect human behavior; simulated conditions are guided by algorithms that do not account for human behavior.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Role of Reservoirs in Drought Management

Reservoir storage and operations play a critical role in drought management in California and greatly influence the timing and magnitude of Delta exports. The CALSIM modeling conducted for BDCP manages reservoirs within operational constraints described above and in detail in Chapter 3 of the Plan. The Plan makes it clear that the plan area does not include these reservoirs. Existing and future BiOps will govern their operations, not the terms of the HCP/NCCP permit. Despite this, the plan

proposed operations with the remanded BiOps masks the striking differences between historic export operations and those proposed under BDCP.

does envision significant changes to the operations of Oroville Reservoir under BDCP.

The 1987-92 simulated operations of the three most important reservoirs—Shasta, Oroville and Folsom—are shown in Figure 3.5. These simulations have important biological implications that are covered in later chapters. For water supply reliability, there are several important observations:

- As noted by the BDCP documentation, the NAA puts a great deal of pressure on upstream reservoirs to meet flow requirements, with Oroville providing most of the operational flexibility. In comparison to historic operations, the NAA significantly reduces storage, and thus carryover, in Shasta and Oroville, but has limited impact on Folsom, with the exception of the last two years of drought.
- Under NAA all three reservoirs are at or near dead pool for the last two years of the drought cycle. Had water-year 1989 been closer in runoff to the other drought years, dead pool conditions would have occurred for the last three years of the six-year drought. Although a statement of the obvious, dead pool limits flexibility in managing water supply and ecosystem needs, both immediately downstream and in the Delta. This is likely to be of greatest concern for managing flow and temperature needs of winter- and spring-run Chinook salmon, particularly under warming climate conditions. Changes in flow releases to meet the needs of listed salmon are highly likely to impact export operations during dry periods. BDCP recognizes this as a concern but does not analyze the likely effects.
- A surprising result of the simulations is that HOS drought operating procedures are more protective of reservoir storage than either NAA or LOS. In an extended drought, storage is more aggressively allocated to either outflow (NAA) or exports (LOS), with both increasing the risk of creating dead pool conditions. This suggests that HOS operating criteria designed to protect smelt, may also do a better job of protecting upstream conditions for salmonids and sturgeon by increasing carryover storage. This, in turn may inadvertently improve water supply resiliency during drought.

It is important to note that a time series analysis of one extended drought within a single simulation record does not give guidance on how the system is likely to perform in all future droughts. Each drought is different, with different storage (reservoir and groundwater) conditions at the start, different precipitation and temperature patterns, and different regulatory or operational responses. To test the above observations more thoroughly, a range of six-year drought scenarios should be simulated and analyzed. Given that most climate models prescribe an increase in frequency and duration of drought, this anecdotal assessment highlights an issue that is likely to occur during the life of the project and have significant impacts on supply as well as ecosystem management.

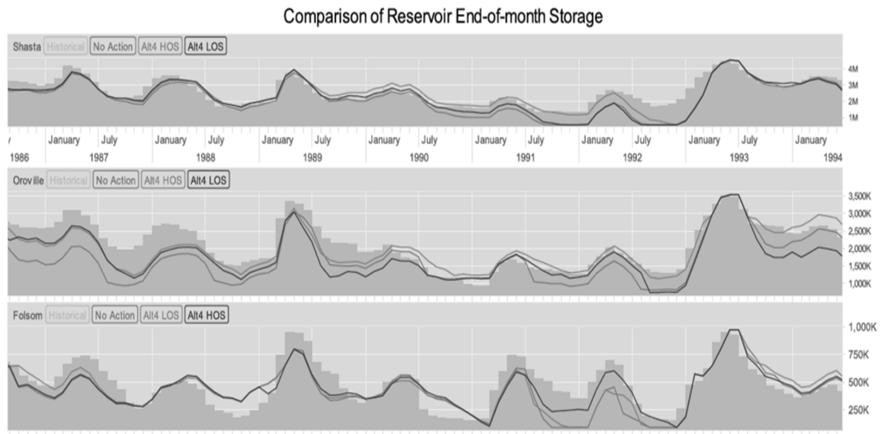


Figure 3.5: End of month storage for HOS, LOS and NAA under ELT conditions simulated for the 1987-92 drought. Historical storage (yellow histogram bars)is plotted for comparison. During the latter stages of the drought, dead pool conditions occur on all three reservoirs. Note that ELT conditions take into account minor changes in climate and sea level rise by 2025 and cannot be compared directly with historical conditions.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

F. Conclusions

The project described in the Draft BDCP and the accompanying Draft EIR/EIR seeks to improve water supply reliability for water exported from the Delta while improving conditions for covered species. An underlying premise for the effort is that adding a second point of diversion, the North Delta facility, operated in conjunction with existing South Delta facilities will allow for more flexible export operations that better support environmental goals and objectives. In concept, this approach appears reasonable and should provide significant flexibility. In practice, however, regulatory and infrastructure constraints, coupled with high upstream consumptive uses of water, severely limits flexibility in operations. These highly constrained operations limit the effectiveness of BDCP in improving water supply reliability.

One of the objectives of BDCP that is in line with those of the Delta Plan is to increase exports during wet periods and decrease them during dry periods when impacts on the ecosystem are greatest. In comparison to the no project alternative, the new facility appears to achieve the former to a modest degree, but it does not significantly reduce pressure on the Delta during drier periods.

The proposed system is particularly vulnerable to extended drought periods (3-6 years). The NAA and LOS lead to dead pool conditions in upstream reservoirs after 3 to 4 years of drought. This decreases water supply reliability during dry periods and, as discussed in later chapters, places at risk species dependent upon reservoir releases, particularly cold-water pool releases. This problem is likely to be particularly acute as climate changes. The surprising result from the model outputs is that the high outflow scenario, principally designed to improve conditions for smelt in the Delta, leads to improved carryover in upstream reservoirs that, in turn, improves year to year water supply reliability and allows for greater flexibility to manage reservoir-dependent species.

The hydrologic modeling effort for BDCP is unprecedented and heroic. However, the tools available for this modeling do not match the information demands. In addition, the plan documents do not do an adequate job of quantifying model uncertainties, particularly those caused by exchanges between 1-, 2- and 3-dimensional models, uncertainties over future conditions, and regulatory behavioral uncertainties. New tools will be needed going forward.

Chapter 4: Environmental Flow Performance: Upstream and Inflows

A. Introduction

The focus of the BDCP is principally on the legal Delta and adjacent Suisun Bay and Marsh, where export operations have the most direct impact on covered species. As discussed in Chapter 3, upstream management, including reservoir operations, consumptive uses of water, and flood management, play a critical role in inflow timing and volume. In this chapter, we examine how conservation measures #1 (water operations) and #2 (Yolo Bypass fisheries) meet conservation objectives that impact listed aquatic species.

The focus of this chapter is on the environmental performance of proposed flow changes in the Sacramento watershed, including the Sacramento, Feather and American Rivers, and inflows to the Delta through the Yolo Bypass and the Sacramento River. Although inflow from the San Joaquin River is important and a determinant of conditions in the South Delta, BDCP does not envision significant changes in flows. For this reason, our analysis is focused only on the Sacramento watershed.

Performance, as used here, is how well actions proposed by BDCP are likely to meet the goals and objectives of the plan. Although there are many issues discussed in the Plan for the Sacramento system and covered species, there are three central flow performance concerns: changes in reservoir release timing and magnitude and its impact on anadromous fishes; modifications to Fremont Weir and its benefits for floodplain habitat for outmigrating salmonids; and, near- and far-field effects of North Delta diversion operations.

B. Impaired Flow in an Impaired System

One of the objectives of BDCP and the Delta Plan—and a concern of many NGOs—is to produce a flow regime with attributes that better support the life history stages of covered aquatic and riparian species. This objective is supported by a large body of national and international literature that has demonstrated how creating more natural flow regimes in highly regulated systems improves conditions for native species.[33] This issue has been at the forefront of controversial efforts by the SWRCB to develop a basin plan that addresses flows.[34]

The Delta's scientific community considers a flow regime that mimics natural seasonal to be fundamental to better species management.[35] Restoring appropriate seasonal and intra-annual variability involves reestablishing flow timing, magnitude, duration, frequency and rates of change that drive key ecosystem attributes that, in turn, support native species (Figure 4.1).

Although restoring elements of the natural flow regime is a worthwhile goal,[36] it should be made clear that in the Delta and its tributaries there is little that remains natural.[37] Added to these physical changes are profound shifts in biological conditions,[38] including a Delta ecosystem dominated by

33. A.H. ARTHINGTON, ENVIRONMENTAL FLOWS: SAVING RIVERS IN THE THIRD MILLENIUM (2012).

34. William E. Fleenor, William A. Bennett, Peter B. Moyle, & Jay R. Lund, *On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta* (2010).

35. Ellen Hanak, Jay Lund, John Durand, William Fleenor, Brian Gray, Josué Medellín-Azuara, Jeffrey Mount, Peter Moyle, Caitrin Phillips & Barton "Buzz" Thompson, *Stress Relief: Prescriptions for a Healthier Delta Ecosystem* (2013).

36. The Bay Institute of San Francisco, *From the Sierra to the Sea: The Ecological History of the San Francisco Bay-Delta Watershed* (1998).

37. Allison Whipple et al., San Francisco Estuary Institute, SACRAMENTO-SAN JOAQUIN DELTA HISTORICAL ECOLOGY INVESTIGATION: EXPLORING PATTERN AND PROCESS (2012), *available at* http://www.sfei.org/sites/default/files/Delta_HistoricalEcology Study_SFEI_ASC_2012_highres.pdf.

38. JAY LUND, ELLEN HANAK, WILLIAM FLEENOR, RICHARD HOWITT, JEFFREY MOUNT & PETER MOYLE, ENVISIONING FUTURES FOR THE SACRAMENTO-SAN JOAQUIN DELTA (2007).

nonnative plants and animals.[39] For this reason, restoring a more naturally variable flow regime in an altered Delta and its watershed, while necessary for improving conditions for covered species, is unlikely to lead, by itself, to their recovery.[40]

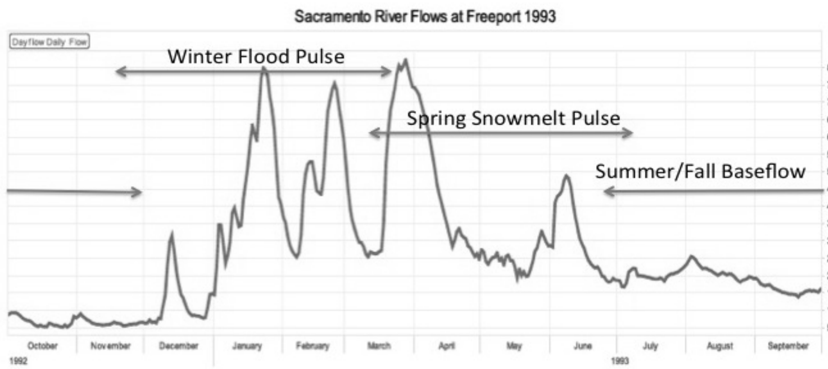


Figure 4.1: Unimpaired Sacramento River flow at Freeport for WY 1992-3 based on DAYFLOW data (DWR). This illustrates the range of natural seasonal variability in flow. Reproduction or migration of aquatic and riparian species is tied to timing, magnitude, frequency, duration and rate of change of flows. Flows, particularly winter and spring flood pulses, are necessary for geomorphic processes that support various life history stages. Flow regulation and land reclamation have significantly altered flow regime (see text for discussion).

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

In this chapter we sought to evaluate BDCP's potential impact on flow regimes upstream and into the Delta. It is infeasible—if not inappropriate—to reconstruct natural flow in the Central Valley given the significant changes in the landscape. Instead, we use *unimpaired flow* (DWR 2007) as a proxy for a more

39. Randall Baxter, Rich Breuer, Larry Brown, Louise Conrad, Fred Freyer, Stephanie Fong, Karen Gehrts, Lenny Grimaldo, Bruce Herbold, Peter Hrodey, Anke Mueller-Solger, Ted Sommer & Kelly Souza, *Interagency Ecological Program 2010 Pelagic Organism Decline Work Plan and Synthesis of Results* (2010), *available at* http://www.water.ca.gov/iep/docs/FinalPOD2010Workplan12610.pdf.

40. JEFFREY MOUNT, WILLIAM BENNETT, JOHN DURAND, WILLIAM FLEENOR, ELLEN HANAK, JAY LUND & PETER MOYLE, AQUATIC ECOSYSTEM STRESSORS IN THE SACRAMENTO-SAN JOAQUIN DELTA (2012).

naturally distributed flow regime.[41] Unimpaired flow is the volume of water that would flow by a given point if no upstream impoundments or diversions were in place. Estimating unimpaired flow is complicated and imprecise, yet is important in setting flow and water quality targets, particularly by the SWRCB. It involves aggregating unimpaired and unregulated runoff from multiple basins that flow to the Delta. Unimpaired flow ignores surface water-groundwater interactions and storage or conveyance of flow in channels, floodplains and wetlands. For this reason, it is not a useful proxy for flow regime on daily time steps, but can be used as an imperfect proxy for annual and monthly flows. We follow that convention in this analysis.

This simplified approach should not be over-interpreted. It is used to assess whether BDCP meets the overall goal of improving ecological conditions by creating a more natural seasonally variable flow regime. It does not address all issues of concern for listed fishes, such as winter- and spring-run Chinook salmon whose primary limitation is due to loss of upstream spawning and rearing habitat and high temperatures in existing channel habitat.[42]

C. Main Rivers of the Sacramento Valley

Multiple biological goals and objectives of BDCP are associated with flow conditions on the Sacramento River and its two main tributaries, the Feather and American Rivers. All anadromous fishes covered by BDCP rely directly on these river systems for spawning, rearing and migration. As noted in Chapter I, we focus here principally on winter- and spring-run Chinook since the BiOps that cover their life history needs have the greatest impact on water operations.

With the exception of proposed changes to the Fremont Weir and the Yolo Bypass (CM#2), BDCP does not envision making significant investments in improving physical habitat upstream of the Delta, or addressing other stressors such as hatcheries, contaminants or harvest procedures.[43] For this reason, most of the impact of BDCP on the Sacramento River and its tributaries upstream of the North Delta facilities will be associated with changes in flow releases from the three major reservoirs: Shasta, Oroville and Folsom.

Simulated average flow conditions affected by changes in reservoir operations under BDCP are summarized in Figure 4.2A-C, including

41. We focus here principally on the rivers that feed into the Delta rather than the Delta per se. An assessment of changes in outflow that occurs in response to changes in operations is contained in Appendix B.

42. *See* John G. Williams, *Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California*. SAN FRANCISCO ESTUARY & WATERSHED SCI., Sept. 2006, *available at* http://escholarship.org/uc/item/21v9x1t7 and JOHN G. WILLIAMS, DRERIP DELTA CONCEPTUAL MODEL: LIFE HISTORY CONCEPTUAL MODEL FOR CHINOOK SALMON & STEELHEAD (2010).

43. *Id.*

Sacramento River at Red Bluff, Feather River below Oroville Reservoir, and American River below Folsom. These flows, along with all other tributaries, aggregate to form the Freeport flow (Figure 4.2D) and the Yolo Bypass. These results include NAA, LOS and HOS flow scenarios and unimpaired flow under the five year-types based on the Sacramento River wetness index.

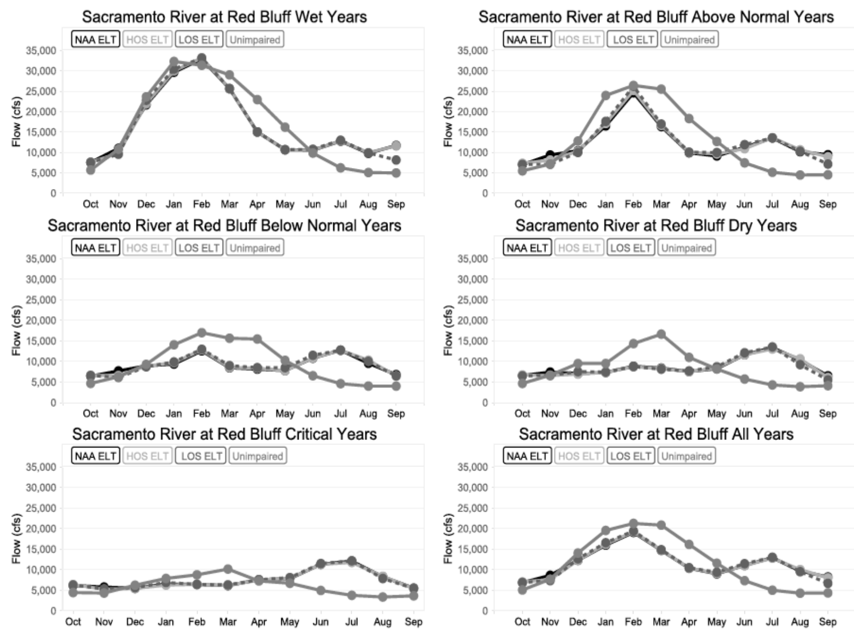


Figure 4.2A: Sacramento River at Red Bluff.

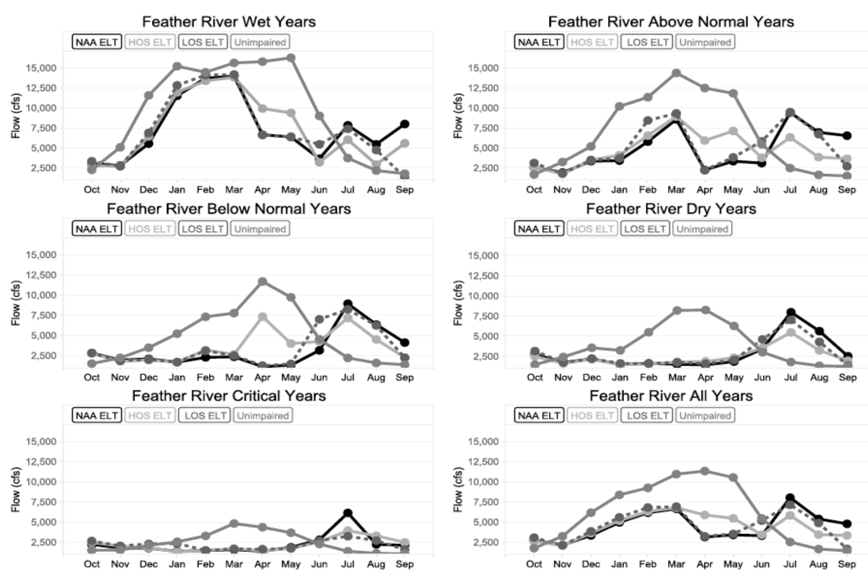


Figure 4.2B: Feather River.

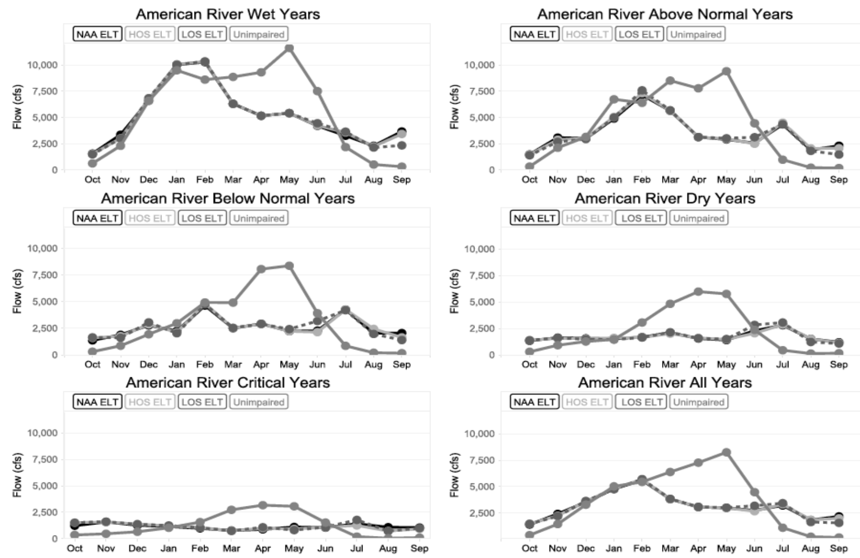


Figure 4.2C: American River.

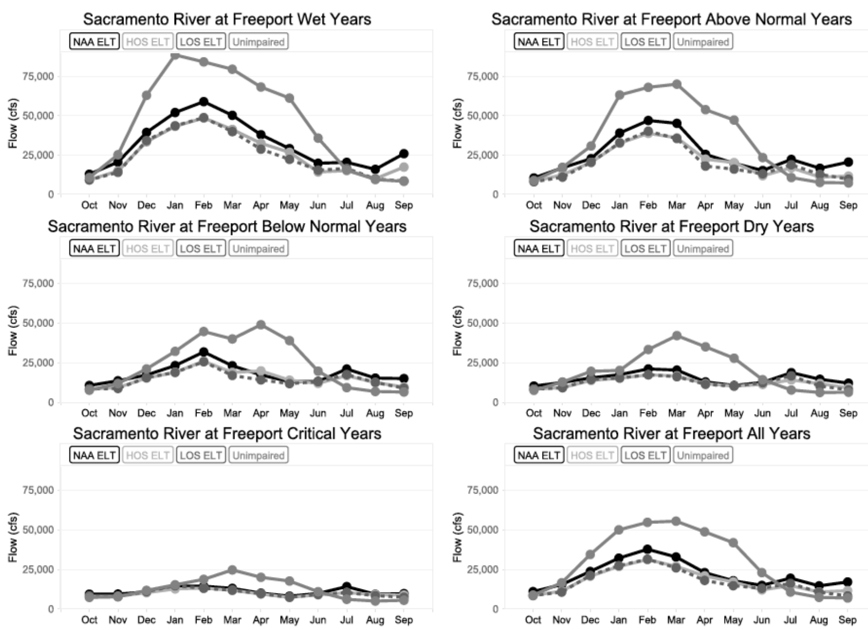


Figure 4.2D: Flow at Freeport. Figures 4.2A-D. Monthly averages sorted by water year types for HOS, LOS, NAA and unimpaired flow. Unimpaired flow is based on current conditions and HOS, LOS and NAA are ELT conditions. See text for discussion. Data from BDCP CALSIM simulations.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

As noted in Chapter 3, the constraints on reservoir operations are significant due to temperature and downstream flow requirements, based mostly on the 2009 BiOp. For this reason, the differences between scenarios are not large. However, a comparison of the impaired and unimpaired flow data allows for several general conclusions about the impact of BDCP on key attributes of Sacramento Valley flow regimes:

Winter Flood Pulse. With the exception of the American River, the winter flood pulse is significantly reduced over unimpaired conditions in the Sacramento Valley. The magnitude of this reduction reflects the size and operations of upstream impoundments relative to the total runoff of the watershed. The most dramatic impairment of winter flood pulses occurs on the Feather River where the pulse is virtually eliminated in most years. There are no substantive differences between LOS, HOS and NAA operations for winter flood pulses. The winter flood pulse is marginally higher under NAA at Freeport, but this reflects more frequent flows down the Yolo Bypass.

Spring Snowmelt Pulse. The rise and gradual recession of flow in the spring is, next to low baseflow conditions in the late summer, the most predictable element of the Sacramento Valley flow regime and is of high biological significance. As shown in Figures 4.2A-D, the spring snowmelt pulse is highly impaired due to impoundments and flow diversions. With the exception of the Feather River, there are no substantive differences between HOS, LOS and NAA impacts on the spring snowmelt pulse in the Sacramento Valley. On the Feather, HOS flow operations designed to improve spring outflow in the Delta, lead to significant improvement in spring conditions in all but dry and critical year types.

Summer/Fall Baseflow. The timing and magnitude of reservoir releases dominates the summer/fall flow regime of the basin (Figure 4.2A-D). These releases are to meet the complex array of temperature and flow requirements downstream of the dams, irrigation demands upstream of the Delta, inflows to meet export demands, and outflows to meet water quality and habitat standards. Summer/fall baseflow flow regimes are highly altered with flows three to five times higher than unimpaired flows. With the exception of the Feather River, BDCP does not change summer/fall baseflow conditions. Under HOS and LOS simulations, the summer flows on the Feather are reduced, creating marginal improvement in flow regime.

Main Rivers Summary

The plan area for BDCP is, by design, limited in scope. The same applies to its conservation measures. The project Plan documents make clear that operations of the CVP and SWP reservoirs are governed by BiOps or FERC licenses, and not BDCP. In addition, they note limited flexibility in reservoir operation due to cold-water pool management, particularly on

Shasta and Folsom Reservoirs. In this way, the reservoirs are in effect another constraint on BDCP,[44] rather than an asset for management.

Yet operations of these reservoirs greatly impact winter- and spring-run Chinook habitat downstream. As shown above, these operations contribute to the significant impairment of flows of the Sacramento River and its major tributaries and are a challenge when trying to meet the biological objectives of BDCP. Additionally, these dams block access to holding, spawning and rearing habitat that has far-reaching effects on winter- and spring-run Chinook salmon populations.[45] These dams also support mitigation hatcheries whose operations may be contributing to harm of native salmon.[46]

It is unclear to us how to disentangle the relationship between the impacts of BDCP—a project designed to meet CVP and SWP water supply needs and an array of associated biological goals and objectives—and operations of SWP and CVP reservoirs. It seems logical to include these reservoirs in BDCP and operate them, along with the new facilities, under a single HCP/NCCP. The modest improvement in Feather River flows not withstanding, the result of this administrative separation is, in effect, to maintain the status quo for the highly impaired flows of the Sacramento system.

D. Yolo Bypass Flows

One of the more prominent conservation measures (CM#2) of BDCP is the modification of the Fremont Weir to promote increases in the frequency of winter and early spring inundation of the Yolo Bypass. A well-established and growing body of evidence, involving monitoring data, field experimentation and, to a lesser extent, life cycle models indicate high benefit of floodplain habitat to foraging juvenile salmon.[47] This stems from the use of high value, off-channel habitat by juveniles, who, under optimal bioenergetic conditions and low predation pressures grow at high rates, increasing their survivorship through the Delta. Fish that either forage on the Yolo Bypass and/or use it as a migration corridor will not be impacted by near-field effects of the proposed North Delta diversion facilities. Fish using the Bypass are also less likely to enter the interior of the Delta where predation pressures are high. Finally, juveniles that use the Bypass leave the Delta later in the season, increasing the likelihood of arriving at the ocean during higher upwelling periods with better food availability.

44. *See* DRAFT BDCP, at Chapter 3.

45. *Id.*

46. PETER B. MOYLE, WILLIAM BENNETT, JOHN DURAND, WILLIAM FLEENOR, BRIAN GRAY, ELLEN HANAK, JAY LUND & JEFFREY MOUNT, WHERE THE WILD THINGS AREN'T: MAKING THE DELTA A BETTER PLACE FOR NATIVE SPECIES (2012).

47. *See* BDPC *documentation for a full summary.*

Currently flow onto the Yolo Bypass from the Sacramento River only occurs when the Verona gauge exceeds 55,000 cfs. Modifications to the Fremont Weir would allow 1,000 cfs to flow onto the floodplain when flow at Verona exceeds 25,000 cfs. Flow through the Weir would climb to 6000 cfs when the river approaches 55,000 cfs. Above 55,000 cfs flow into the Bypass would be similar to NAA conditions. In addition to allowing flood flows, the weir would be modified to allow 100 cfs attraction flows to a fish ladder to improve upstream passage of adult salmon, steelhead and sturgeon (passage issues not evaluated here).

The average annual flow of the Yolo Bypass is approximately 1.5 maf. Under NAA, HOS and LOS, this amount would not differ significantly since the majority of flow volume on the Bypass occurs when the Sacramento overtops Fremont Weir and the Sacramento Weir (Figure 4.3). However, the timing, frequency, and duration of floodplain inundation—key elements of the natural flow regime—would change substantially with the proposed modification of Fremont Weir.

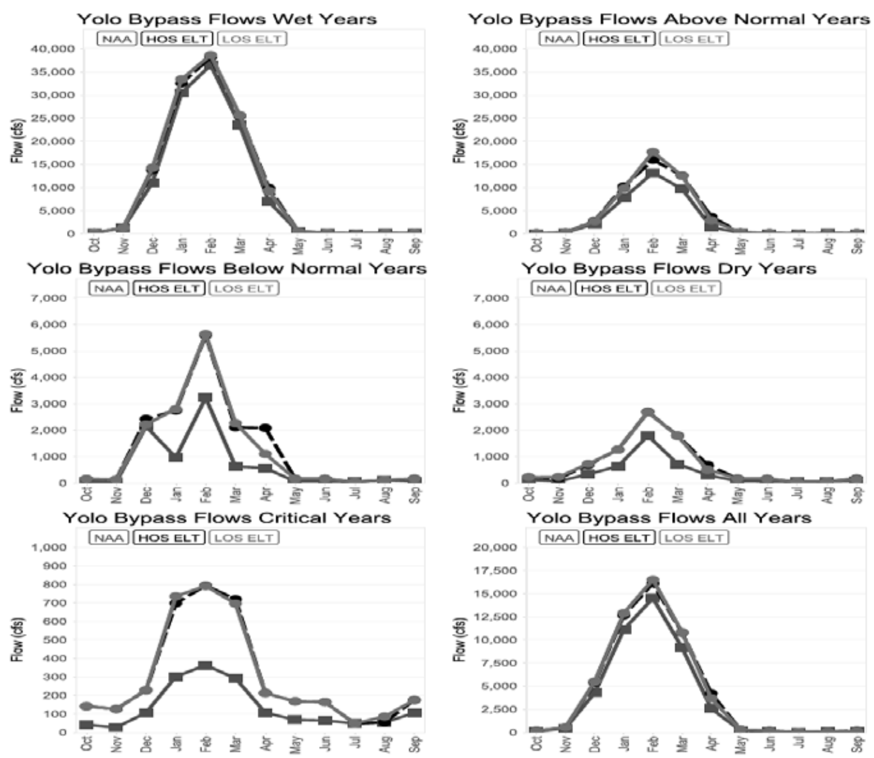


Figure 4.3: Average monthly flows for the Yolo Bypass under HOS, LOS and NAA under ELT conditions for different year types. Note changes in scale.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Flood Frequency. The frequency of inundation of the Bypass increases significantly under BDCP. Under current conditions there is a roughly 40% annual probability of flooding on the Yolo Bypass. Under BDCP this increases to more than 70% annual probability. The largest change occurs in drier years (Figure 4.3).

Flood Duration. Multiple studies have shown that flood duration, which allows for nutrient cycling and primary production, is essential for supporting juvenile salmonid foraging.[48] Modifications to Fremont Weir increase flood durations with high habitat benefits. Under current operations, flood durations aggregate to an average of 25 days per year. This would not change under NAA in the ELT. Under both HOS and LOS ELT this would increase more than three-fold to an average of 81 days per year.

Flood Timing. In addition to more frequent, longer-lasting flooding conditions, modifications to the Fremont Weir would expand the flood season, particularly in drier years (Figure 4.3). This expansion helps divert early migrants, such as winter-run Chinook salmon and later migrants, such as spring-run and fall-run Chinook, onto the floodplain. For example, based on BDCP data, we estimate that days of flooding above 1000 cfs on the Bypass will more than double in January and triple in April.

Yolo Bypass Performance for Listed Salmon

Although CM#2 achieves the broader objective of improving the amount and quality of floodplain habitat, principally by restoring a more natural flow regime, it's effectiveness in supporting federally listed species of salmon (the focus of this review) is somewhat limited. The BDCP consultants modeled the overall benefits of the Yolo Bypass flows to out-migrating and foraging juveniles. For winter-run Chinook salmon, the benefits were modest with an estimate 1% to 8% increase in escapement. The limited benefit of the Yolo Bypass is, according to the BDCP model results, due to the small percentage of juveniles likely to be diverted onto the floodplain. This stems from the fact that most migration begins in December and January coincident with the first pulse flows of the season and does not coincide with peak inundation periods of the Bypass.

Greater benefit, albeit still limited, occurs for spring-run Chinook salmon. The bulk of juvenile out-migration takes place during the optimal months for floodplain inundation: February through March. However, two factors reduce the effectiveness of Yolo Bypass for spring-run according to BDCP documents. The majority of spring-run Chinook salmon come from hatcheries in the Feather River. Juveniles leaving the Feather are only diverted onto the Yolo Bypass during rare high flow events, leaving the Sacramento River as their principal migration route to the Delta. Naturally spawned fish in Butte Creek use the Sutter Bypass as their principal

48. *See* Williams, *supra* note 10.

migration route. Like Feather River fish, they too only move access the Yolo Bypass during rare high flow events. Naturally spawned spring-run in Battle, Clear, Mill and Deer Creek pass Fremont Weir on their out-migration paths and will benefit most from likely access to the Bypass.

Second, according to BDCP models, most spring-run juveniles reach the Delta, and presumably the Yolo Bypass, as yearling smolts. In this stage, they are presumed by BDCP consultants to not take full advantage of the high quality foraging conditions of the Bypass, but use it principally as a migration corridor. BDCP consultants estimate that 90% of spring-run Chinook in the Yolo Bypass are migrants, rather than foraging fish. The BDCP consultants readily note that this proportion reflects the split between migrants and foraging characteristics in hatchery fish and may not be indicative of proportions of wild fish. Our consultation with several salmon biologists suggests that the distinction between foragers and migrants is arbitrary and likely does not reflect actual behavior of juveniles on the Bypass. In addition, there is emerging evidence that a high percentage of naturally spawned fish move out as fry and migrate during high winter flows.[49]

The BDCP consultants used several approaches to model the effect of the Yolo Bypass on survivorship. They acknowledge that current modeling tools are not well-suited to this kind of analysis. They developed a simple bioenergetic model for floodplain rearing, but told the panel that they felt it did not fully capture the benefits of the Bypass, and that their estimates of survivorship were conservatively low. Despite these limitations the BDCP models along with a growing body of literature suggest that spring-run juveniles as well as winter-run juveniles that access the Bypass are likely to have significantly higher survival rates to Chipps Island and presumably higher adult escapement.[50]

Yolo Bypass Summary

CM#2 has high potential to benefit a range of covered species. Its benefit for winter- and spring-run Chinook is muted due to outmigration timing (winter-run) or the structural difficulty in diverting Feather River and Butte Creek fish (spring-run) onto the Bypass. Yet even with these concerns, there are likely to be improvements in survivorship associated with an

49. Peter B. Moyle, Joseph D. Kiernan, Patrick K. Crain & Rebecca M. Quiñones, *Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach*, PLOS ONE, May 22, 2013, *available at* http://www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0063883&representation=PDF.

50. The focus of this chapter is on spring- and winter-run Chinook. There is very significant benefit to other covered species, particularly fall-run Chinook and Sacramento splittail that can take advantage of Yolo Bypass flooding more readily.

alternative migration corridor with high value foraging habitat. There is an adaptive management program being developed for the Yolo Bypass that will be incorporated into BDCP. This effort would benefit BDCP objectives by conducting experiments and modeling that test ways to improve access of listed salmon onto the Bypass. This can include modifications to the Fremont Weir or pulse flow releases that improve winter-run diversion. Along with modification of Fremont Weir, this program may also want to consider the potential for using the Sacramento Weir to divert Feather River and Butte Creek fish. Regardless, as outlined below, a more aggressive approach to developing an alternative migration corridor for winter- and spring-run Chinook is likely to be necessary to mitigate the effects of the new North Delta facility.

E. North Delta Facility Impacts and Mitigation

The new point of diversion along the Sacramento River is likely to impact all covered fish that either use the main channel of the Sacramento for migration or rearing, or are indirectly affected by downstream changes in flow volume and timing. These impacts are some of the most difficult to assess due to uncertainties about design and operation of the facilities (no comparable facility exists to calibrate models) and the relationship between downstream actions, such as tidal marsh restoration, and flows. This section assesses BDCP's evaluation of near-field (adjacent to the facility) and far-field (downstream from the facility) effects.

Near Field Effects

The preferred project involves the construction of three screened intakes along the left bank of the Sacramento River in the vicinity of the town of Hood. Each screen will be capable of withdrawing up to 3,000 cfs. In our view, the BDCP consultants have properly identified the two main sources of near field effects of the facility on out-migrating salmonids: losses due to impingement on the intake screens and losses due to predation near the diversion. However, we are uncertain about the effectiveness of proposed mitigation for these effects.

To mitigate for impingement potential, the consultants propose real-time management of pumping regimes relative to channel flow in order to maintain approach and sweeping velocities that reduce contact with intake screens. This real-time management would be informed by upstream monitoring of outmigrants. This issue remains a high uncertainty for operations of the facility ("low certainty" in the parlance of BDCP). Conceptually, a good adaptive management and research program coupled with real-time management could reduce impacts. However, as of this writing, the specifics of this program are not provided by BDCP (see discussion in Chapters 8 and 9 of this report) and we are unable to evaluate how effective it might be.

A greater near field effect of the facility is the high likelihood of concentration of predators near the facility, with resulting losses of migrants and foragers due to predation. Predators take advantage of concentrated prey and velocity refugia at physical structures throughout the Delta[51] and will presumably do the same at the North Delta intake facilities. The BDCP consultants use various modeling approaches to estimate potential predation losses, including comparison with estimates of losses at known structures such as diversion screens of the Glenn-Colusa Irrigation District. Estimated predation losses for juvenile winter run Chinook that pass the facility vary from as low as 1% to as high as 12% (we did not find statistics for spring-run Chinook salmon losses). The higher predation loss values would have significant population-level impacts on winter-run Chinook and would fail to meet objectives of BDCP. The consultants acknowledge high levels of uncertainty about predation effects at the facility. The solution, as with most issues with high uncertainty in BDCP, is to defer this to adaptive management of the project, including unspecified predator control programs and real time management of flows. Based on our experience in the Delta, we consider this to be a significant, unresolved management issue.

Far Field Effects

The North Delta facility is expected to provide an average of roughly half of the exports from the Delta. As outlined in Chapter 3, operations of the facility are highly constrained by flow and water quality regulations, upstream water use, reservoir operations and hydrology. The simulated operations of the North Delta facility are summarized in Figure 4.4, including a measure of the proportion of channel flow that is diverted.

There are significant seasonal and interannual variations in operation of the North Delta facility that will drive far field effects.[52] During wet and above average water years, pumping regimes are most aggressive, particularly during the summer and early fall when 25% to as much as 39% of

51. DAVID A. VOGEL, CAL. DEP'T OF WATER RES., PILOT STUDY TO EVALUATE ACOUSTIC-TAGGED JUVENILE CHINOOK SALMON SMOLT MIGRATION IN THE NORTHERN SACRAMENTO–SAN JOAQUIN DELTA, 2006-2007 (2008).

52. We did not evaluate the effects of size of the facility and its level of use. However, it is worth noting in Figure 4.4 how often average monthly exports approach facility capacity. Using a monthly average greater than 8,000 cfs as an indicator of periodic use of full capacity, this only occurs in February and March in wet years and March of above average years. This is roughly 5% of the total months, suggesting that operational and regulatory constraints, rather than facility size, determine export volumes.

channel flow is diverted. Diversions, as a percentage of channel flow, decline dramatically in below normal, dry and critical years. In addition, pumping regimes are highly protective of channel flow in December, reflecting the restrictions on exports to protect initial pulse flows for winter-run Chinook. As expected, the HOS scenario, designed to improve Delta outflow, results in the most protective pumping regime for bypass flows at the North Delta facility.

BDCP documents acknowledge that the reductions in bypass flow create multiple far field effects that impact listed salmon. These include reduced attraction flows for migrating adult salmon, increased losses of juvenile salmon migrants and foragers due to longer transit times to the Delta, and diversion into the interior Delta where predation and/or entrainment losses are high. These operations also affect total Delta outflow.[53]

The BDCP consultants use multiple modeling approaches to address the far field effects of the North Delta facility. The main model used is the Delta Passage Model (DPM) that tracks smolt survival through the Delta. This model and others summarized in Appendix 5C of the Effects Analysis all draw the same conclusion: There is an increase in losses of winter- and spring-run Chinook salmon migrants associated with reduced flows in the bypass reach from Hood to Rio Vista. The magnitude of this impact varies depending upon year type (wetter years have reduced losses) and magnitude of flow reduction associated with pumping (up to 35% decreases in flows during some migration periods). These results are not surprising since there is a long-established relationship between transit time and survivorship for smolts leaving the Sacramento River.[54]

53. Appendix B presents a summary of Delta outflow and the magnitude of impairment of flows from the Sacramento Valley. The latter uses a simplified impairment index.

54. *See* Ken B. Newman, *Modeling Paired Release-Recovery Data in the Presence of Survival and Capture Heterogeneity with Application to Marked Juvenile Salmon*, 3 STATISTICAL MODELING 157 (2003).*and* Russell W. Perry, John R. Skalski, Patricia L. Brandes, Philip T. Sandstrom, A. Peter Klimley, Arnold Amman & Bruce MacFarlane, *Estimating Survival and Migration Route Probabilities of Juvenile Chinook Salmon in the Sacramento–San Joaquin River Delta*, 30 N. AM. J. FISHERIES MGMT. 142 (2010).

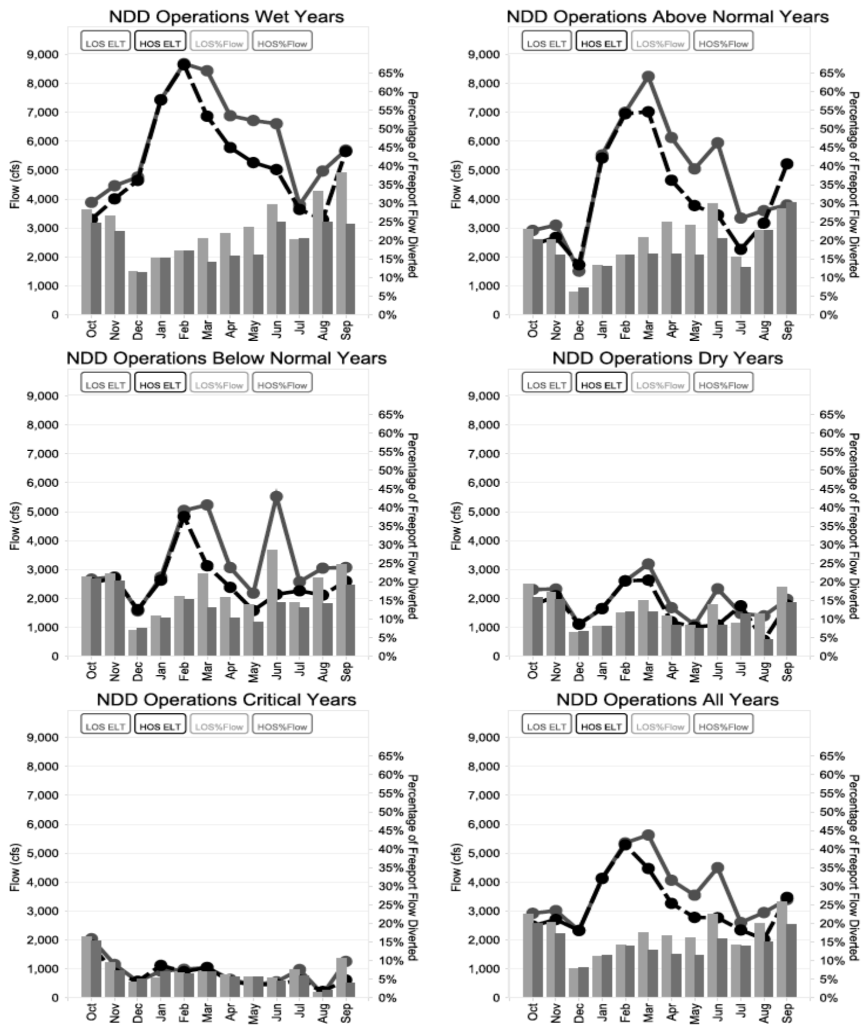


Figure 4.4. Average monthly export flows of North Delta diversion facility under HOS and LOS ELT for different year types, and percentage of total bypass channel flow exported.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

BDCP proposes to mitigate the increase in losses of smolts associated with far-field effects through seven strategies:

- Tiered pumping regimes to reduce withdrawals during the initial winter flood pulse (described in Chapter 3).
- Real-time operational changes that reduce export pumping when monitoring indicates that large numbers of migrants have entered the reach upstream of the facility.

- Flow management that reduces tidal reversals at Georgiana Slough, decreasing the likelihood of smolts diverting into the interior of the Delta.
- Nonphysical barriers at Georgiana Slough.
- Reductions in entrainment at the South Delta facility due to reduced export pumping.
- Increased diversion of foragers and migrants onto the Yolo Bypass.
- Improved channel margin, floodplain and tidal marsh habitat to support foraging juveniles.

The benefits of the last of these strategies—habitat restoration—are not captured in the survivorship modeling that was completed by BDCP consultants (see chapter 7 for a discussion). In addition, the models do not incorporate real-time operations adjustments since the scope and terms of these operations have yet to be determined. The remaining strategies are incorporated into models used to assess smolt survivorship. Closely examined, BDCP model results indicate that these measures, in combination, roughly offset the losses created by reductions in flows and increases in predation in the bypass reach, meeting the standard of mitigation. There is no indication that these actions would result in substantial improvement in conditions for listed salmon. This includes the Yolo Bypass, which provides significant benefits for other covered species.

North Delta Facility Summary

We have not had sufficient time or resources to conduct a detailed review of the models used to assess survivorship in the bypass reach and the effectiveness of mitigation efforts. Overall, most of the models used for near and far field impacts are standard Delta models. Model results seem reasonable and fall within the boundaries of current understanding. This suggests that they provide an acceptable first-order approximation useful enough as a basis for further analysis and adaptive management experiments.

We view the efforts to model the effectiveness of predator management and nonphysical barriers as having high uncertainty. In addition, as noted, there is insufficient detail on real-time management to assess its likelihood for success. The flow modeling that was done on the bypass reach makes assumptions about tidal marsh restoration in the Cache Slough area. This restoration plays an important role in tidal energy and efforts to manage flow reversals at Georgiana Slough. We are uncertain about both the impact of this tidal marsh restoration and, if modeled correctly, whether the assumed restoration would be completed in the ELT. This same issue applies to the Yolo Bypass. Scheduling contained in BDCP suggests that the Yolo Bypass project would not be complete until after the North Delta facility. This lag in completion hampers efforts to mitigate for the project. At minimum, given the large uncertainties, it seems prudent to have all mitigation efforts in place and tested prior to initiating operation of the diversion facilities.

F. Conclusion

To meet its biological goals and objectives, BDCP has developed 22 conservation measures. Two of these measures—CM#1, Water Operations, and CM#2, Yolo Bypass—are intended to create significant improvement in conditions for covered fishes by creating more natural flow conditions, improving fish passage and, in the case of the Yolo Bypass, improving floodplain spawning and rearing habitat. We focused our assessment on how CM#1 and CM#2 performed for winter and spring-run Chinook in this regard.

In general, we found that CM#1 does not significantly change the highly impaired flow regime upstream of the Yolo Bypass and Freeport, with the exception of an increase in spring flows on the Feather River under the HOS flow scenario (nor does it change outflows much[55]). BDCP proponents have made the strategic decision to focus principally on the Delta, rather than including CVP and SWP reservoirs that regulate flow into the Delta. This limits BDCP's effectiveness in its conservation measures since it does not address the major risk factors for listed salmon.

We found the increased frequency of flows into the Yolo Bypass to be an important step in restoring floodplain habitat. However, timing of outmigration and current design of CM#2 modifications limit the impact of this effort for listed salmon. The current adaptive management program underway for the Yolo Bypass needs to address this issue, including considering changing reservoir operations and alternative ways to divert fish into the Bypass.

Near field and far field effects of the North Delta facility have the potential to significantly reduce survivorship if not fully mitigated. Uncertainties over mitigation are high and will require a robust adaptive management plan. In our view, the Yolo Bypass program should be viewed as mitigation for the impacts of the North Delta facility on listed salmon. CM#2, along with all other mitigation efforts, need to be in place prior to operation of the facility.

Chapter 5: In-Delta Flow Performance

A. Introduction

BDCP Conservation Measure #1 (CM#1) aims to restore more natural net flows (i.e., net seaward) within the Delta by adding a point of diversion upstream of the Delta:

55. *See* DRAFT BDCP, at Appendix B.

> Conservation Measure #1: "Construction and operation of the new north Delta intakes are designed to substantially reduce the *incidence of reverse flow*[56] and restore a *predominantly east-west flow pattern in the* San Joaquin River.[57] (Page 3.4-7, emphasis added).

This statement implies two classes of presumed effects that south Delta diversions induce through altered flows: direct effects whereby reversed flows in the south Delta contribute to entrainment of fish at the Delta export facilities, and indirect effects whereby changes in flow in the lower San Joaquin River are believed to alter the survival or migratory success of fish in the affected channels. Both of these presumed effects refer to net flows, which are determined by averaging out the substantial tidal flows that reverse direction twice daily. Although these net flows are small compared to tidal flows in much of the Delta, there is evidence that they can have substantial effects on some fish species.

In this chapter we evaluate changes in net flows in the Delta associated with changes in operations and the construction of the new facility. As in Chapters 3 and 4, we evaluate the differences between HOS and LOS scenarios and compare then to NAA, the no-project alternative. All of these analyses are in the Early Long-Term (ELT) shortly after the beginning of operations of the North Delta facility.

B. Concerns over modeling

As noted in Chapter 1 of this review, we have concerns over the use and over-interpretation of the modeling data provided to us. In conducting our analysis for this chapter and the following chapter on impacts of outflows on smelt, we have relied on output from CALSIM under various scenarios. Our analysis revealed several apparent anomalies in model output. Although we received clear explanations of the origin of these anomalies from the BDCP consultants, we remain concerned that the model output is unrealistic for projecting actual project operations and the resultant flows. In particular, certain modeled conditions arise through artifact that provide substantial improvements in conditions for delta smelt. Thus, conclusions drawn on the basis of these models rest on an unreliable foundation. These concerns are focused on Delta outflow during fall and southward flow in the southern Delta during winter. These flows have been linked to habitat or survival of delta smelt.

56. Draft BDCP, at Section 3.4.1.4.3, *Flow Criteria* (emphasis added).

57. *Id.* at 3.4-7 (emphasis added).

October

The USFWS Biological Opinion for delta smelt includes a fall X2 standard that applies following wet springs. Flows are usually low during this season so small variations in flow can have substantial effects on the location and area of the low-salinity zone, and hence potentially on habitat conditions for smelt.

For various reasons X2 calculated by CALSIM differs substantially from that determined from outflow as in Jassby et al. (1995).[58] We therefore focused on outflow as determined by CALSIM, rather than X2 as provided by BDCP modelers.

For this analysis we sorted flow data into a ranked time series from lowest to highest. In Octobers of most years in the drier half of the time series, outflow under HOS and LOS is much higher than under NAA (Figure 5.1). During the half of the years with the lowest inflow, outflow under HOS and LOS is up to twice that under NAA (median 77% higher for these 41 years). By contrast, during years of high inflow (right-hand half of Figure 1), HOS and NAA outflows roughly track each other, while LOS is much lower because the fall X2 requirement does not apply to that scenario. This anomaly is not balanced by flows in other fall months; although a few anomalies like those found in October crop up as well in November. For the most part either all three outflows track each other or LOS is lower, presumably because of the lack of a fall X2 requirement.

To our knowledge there is no regulatory or operational requirement for reduced outflow under NAA or increased outflow under HOS or LOS in dry Octobers. Furthermore, there would be no reason to focus such a requirement in only one month if it were meant to benefit delta smelt, since they are present in the low-salinity zone from summer through fall. Outflow in fall can affect delta smelt recruitment so the modeled outflows can result in considerable differences in predicted recruitment under the three modeled scenarios (Chapter 6). We do not find these differences compelling because of a lack of a regulatory or other basis for the high outflows under HOS and LOS in dry Octobers.

58. Alan D. Jassby, Wim. J. Kimmerer, Stephen G. Monismith, Charles Armor, James E. Cloern, Thomas M. Powell, Jerry R. Schubel, Timothy J. Vendlinski, *Isohaline Position as a Habitat Indicator for Estuarine Populations*, 5(1) ECOLOGICAL APPLICATIONS 272 (1995).

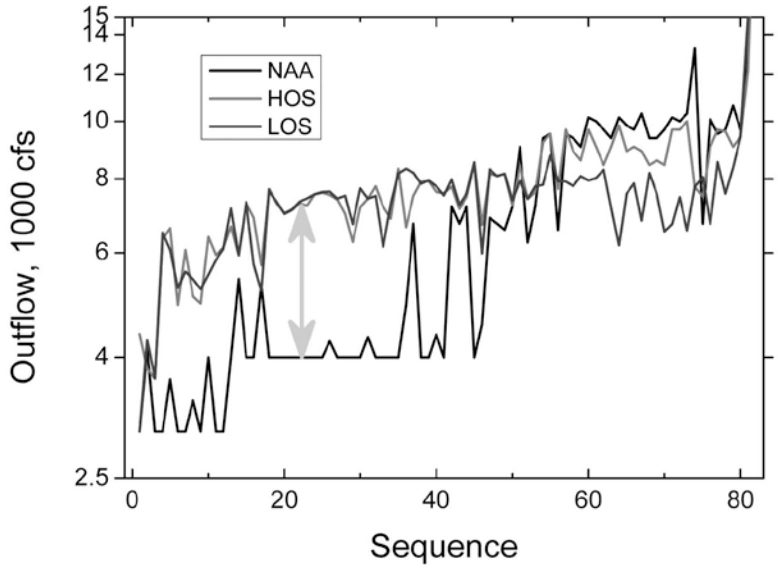


Figure 5.1. Net Delta outflow in October under the three scenarios sorted by inflow as determined by CALSIM under NAA; i.e., sequence 1 is the lowest inflow and 82 the highest. The gray arrow points out the region of interest where outflow under HOS and LOS is as much as double that under NAA. Outflow is plotted on a log scale to show proportional differences among scenarios especially at low flows, and because X2 can be modeled as a function of the log of outflow. The highest two outflows have been cut off to focus the figure on the lower values.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

January

January has been the month of greatest adult delta smelt entrainment historically, so the modeled conditions in January can have large impacts on forecasts of adult survival. The CALSIM modeling included a requirement that OMR flows during January be zero in wet years, no more negative than -3,500 cfs in above-normal and below-normal years, and no more negative than -5,000 cfs in dry and critical years. However, no estimates of current year type are possible in January, and rather than presume perfect foresight or use information available up to that point the modelers chose to operate the simulated system for January using the requirements that applied to the previous year type. Because dry Januaries can follow wet years, this resulted in an anomalous condition in which requirements for wet years applied during dry Januaries.

As a result of this anomaly, the modeled scenarios (LOS and HOS) called for reductions in export flows in Januaries following wet years, which substantially increased OMR during many Januaries at the dry end of the historical range for that month (Figure 5.2). This is unrealistic for several reasons. First, the actual values don't conform to the model requirements of 0 cfs, -3,500 cfs or -5,000 cfs, depending on previous year type; instead they are quite variable and achieve zero rarely (Figure 5.2). Thus, there is no clear regulatory basis for these flows.

Second, the reduction in export flows was sometimes accomplished through increased outflow rather than reduced reservoir releases or increased exports from the North Delta. Thus, many January outflows during dry periods were very much greater than the corresponding flows of the NAA alternative.

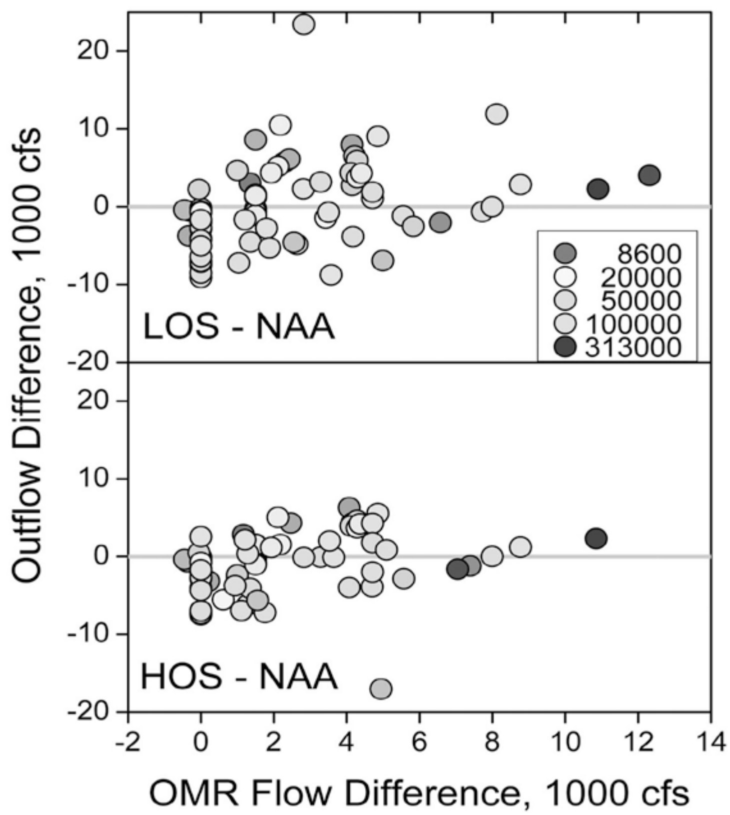


Figure 5.2. January flow conditions compared between the two modeled scenarios (LOS, top; HOS, bottom) as the differences from the flows under NAA. The colors show the range of NAA inflow. Under the LOS there were many Januaries when inflow was low but the outflow and OMR flow were increased by about the same amount over NAA.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Consequences

The anomalies discussed above seem to arise through the application of rules and constraints designed in some cases for real-time operations, using a model with a monthly time step. We understand and appreciate the difficulty in modeling such a complex system and the problems that would arise in attempting to mimic variation on a daily time scale. Furthermore, we trust that the modeling team has made every effort to produce output that conforms to the constraints and the modeled hydrology. Nevertheless, the specific model outputs we focus on above seem unrealistic, particularly since these anomalies are largely confined to October and January. We do not think the system is likely to be operated in real-time to achieve the flows shown in model output.

Thus, discussions in this and the next chapter should be accompanied with this caveat: *these apply only if the system were actually to be operated to achieve the flows indicated by the models*. If rules are not in place to ensure these flows are achieved, the benefits to delta smelt (and presumably other species) will not be realized.

C. Analysis of flows

Construction of a new export facility will not by itself achieve the goals of restoring more natural flow patterns in the Delta; the effects of such a facility are entirely dependent upon its operational rules. We assessed how much the modeled operational scenarios (HOS and LOS) achieve the goals of restoring net natural flow directions within the Delta. In recent years, the Biological Opinions for delta smelt and salmonids have directed attention to net flows in OMR, which are the main channels carrying Sacramento water to the export facilities in the south Delta. OMR flows show relationships with salvage of some fish species at the fish facilities and are presumed to reflect entrainment risk to fish in the Delta, i.e., the direct effects of the projects. In earlier years, focus was on net flows in the lower San Joaquin River (QWEST) as a more general measure of the impacts of water management on net flows in the Delta, which were believed to cause indirect effects on fish populations.

OMR and QWEST flows are two measures for the effectiveness of CM#1 in restoring more seaward flows in the Delta (see Chapter 6 for an estimate of effects of the modeled flows on delta smelt entrainment). Here we examine both the changes in seaward flows and the degree of negative flows as predicted from CALSIM models.

A north Delta diversion will increase the frequency of positive net OMR and QWEST flows and reduce negative values to the extent that exports from the north Delta reduce exports from the south Delta. However, BDCP calls for continued use of south Delta diversion facilities and greatly restricts the operation of the north Delta diversion, particularly in the early winter. Thus, restoration of seaward flows in the Delta must be viewed in the context of the timing and conditions when the north Delta diversion can be used.

We describe how LOS and HOS alter the incidence and degree of reverse flows during the seasons of sensitivity for the covered fish. For each season of sensitivity, we group results by quartiles of outflow to assess how changes in flows occur under drier versus wetter conditions. Low flows in the winter and spring are when concern over reverse flows is greatest for most species.

Direct effects

Direct effects are entrainment, or the number of fish diverted into the facilities. This number is not known for any species because substantial numbers of fish are lost in the waterways leading to the fish facilities and through the louvers at the fish facilities. Salvage is therefore a poor measure of entrainment effects, but there are no other direct measures. Estimates of entrainment as a proportion of total population of delta smelt are presented in Chapter 6. Such an analysis has not been developed for any other species of concern. Therefore, to broaden the analysis to all species we examined changes in modeled flows in OMR. This measure has been used in both Biological Opinions. OMR is both calculated by models and measured in the field; it is roughly equal to San Joaquin inflow minus total exports. Because San Joaquin inflows are less than total exports under all but flood conditions, OMR flows are usually negative. We assume OMR is the primary focus of CM #1's goal to "reduce the incidence of reverse flow." To broaden the question we also assess the degree to which flows are made less negative by the alternatives.

Incidence of reverse flow

Because "incidence" is a measure of frequency, the "Incidence of reverse flows" is the frequency with which OMR is changed from negative under the no action alternative to zero or positive (northward) under the proposed alternative; because model output is available by month, we examined frequency on a monthly basis (Table 1). The distribution across months of the change in net OMR direction implies that effects on each species will depend on its season of sensitivity.

The results below are consistent with the goal of CM#1 of achieving a greater frequency of positive net flows in Delta channels by shifting exports to the north Delta diversion site. This is true more for HOS than LOS operations.

LOS effects. The LOS reduced the incidence of negative flows by 5% overall (50 months out of the 984 months modeled; Table 1). Under NAA 110 months had positive (northward) OMR flows while 160 months had positive flows under LOS. Positive or zero OMR flows under LOS coincided with negative flows under NAA in all months save August, but most frequently in January-March. There were 21 months when OMR flows were positive under NAA but negative under LOS in April and May (Table 1).

The shift to positive OMR flows under LOS was sometimes quite large (about 6,000 cfs) and occurred almost solely under higher river inflows during December through June. The occasions when NAA alone produced positive OMR flow occurred only in April and May and the change in OMR flows between NAA and LOS were small (<1,000 cfs).

HOS effects. The HOS had a more substantial effect on the incidence of negative flows than LOS (Table 5.1). There were only 13 instances when positive OMR flows under NAA were negative under the HOS, and the differences were very small in those cases. As with LOS, the changed OMR status happened in all months save August. The most noticeable difference between HOS and the other two alternatives was in September and November when HOS was northward about a third of the time while NAA was always southward and LOS northward only a few times. The low frequency of northward flows under HOS in October may be related to the anomalies in outflow identified above, but the reasons for the otherwise high frequency of positive OMR flows in fall under HOS are obscure, as they are not called for by regulations and no fishes of concern are vulnerable to export entrainment at that time.

Table 5.1. Frequency by Month of Northward (including a few zero flows) or Southward Flows Under NAA vs. LOS, and NAA vs. HOS. Columns in italics indicate those years and months when the direction of flow differed between NAA and the selected scenario. For example, in April there were 47 years when NAA flow was northward, in 5 of which LOS was southward, and 35 years when both flows were southward, out of a total of 82 years.

Month	**NAA North**		**NAA South**		**All LOS North**	**NAA North**		**NAA South**		**All HOS North**
	LOS North	LOS *South*	LOS *North*	LOS South		HOS North	HOS *South*	HOS *North*	HOS South	
Oct	0	0	1	81	**1**	0	0	8	74	**8**
Nov	0	0	2	80	**2**	0	0	25	57	**25**
Dec	3	0	1	78	**4**	3	0	0	79	**3**
Jan	4	0	11	67	**15**	4	0	12	66	**16**
Feb	8	0	18	56	**26**	8	0	19	55	**27**
Mar	6	0	25	51	**31**	6	0	36	40	**42**
Apr	42	5	0	35	**42**	44	3	5	30	**49**
May	25	16	0	41	**25**	31	10	6	35	**37**
Jun	1	0	9	72	**10**	1	0	9	72	**10**
Jul	0	0	1	81	**1**	0	0	1	81	**1**
Aug	0	0	0	82	**0**	0	0	0	82	**0**
Sep	0	0	3	79	**3**	0	0	38	44	**38**
All months	89	21	71	803	**160**	97	13	159	715	**256**

Magnitude of negative OMR flows

Entrainment rates are a function of population distribution and abundance, season of occurrence in the Delta, and flow conditions including export rates (or OMR conditions). The months of vulnerability for each species of concern were taken from the BDCP documents. For adult longfin and delta smelt the season of vulnerability is from December through March. For juvenile delta smelt the season is from March through June.

The effects of overall flow conditions, i.e., how relatively wet or dry it is, are assessed by grouping the months of vulnerability for all 82 modeled years into quartiles of outflow in the NAA; e.g., for adult delta smelt which are considered vulnerable during December-March, there were 82 months in each quartile of outflow. We examined conditions of OMR, river inflow and outflow under several operational scenarios. We examined differences under four levels of wetness for each month using outflow in the month as a measure of wetness. Historically fish are more often salvaged under drier conditions than under wet and during their season of vulnerability.

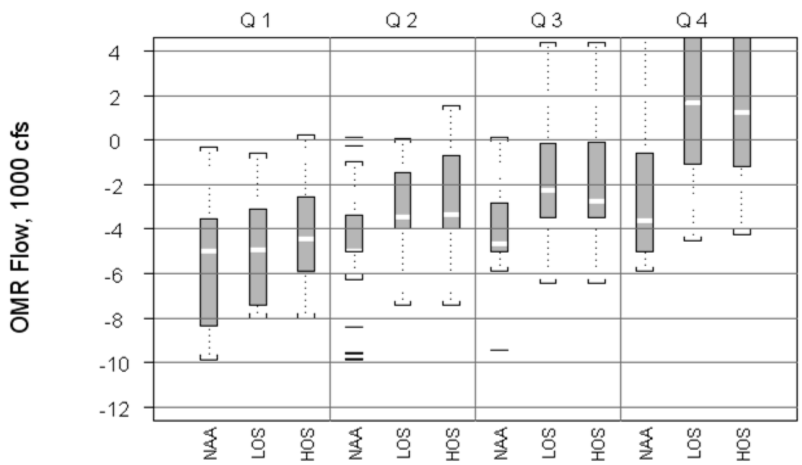
In Figure 5.3 we present comparisons of the HOS and LOS scenarios for each quartile of outflow (under the NAA scenario to ensure comparison of the same years in each graph). Under the HOS and LOS alternatives, OMR differs from NAA during the seasons of sensitivity for adult delta smelt (December-March) and juvenile delta smelt (April-June).

Three patterns can be seen:

(1) In the season of vulnerability for adult smelt (December-March), HOS and LOS both show about a 1,000cfs to 5,000 cfs increase toward positive in OMR under all quartiles of outflow, but all OMR values are strongly negative except in the wettest quartile of the data. Exports in December and January can be high and the use of a north Delta diversion can improve OMR (but see "Concerns over modeling" above). For juvenile smelt, the increase in OMR flow under LOS and HOS is smaller and less consistent. In all cases the level of OMR flow is much less negative than in December-March.

(2) The HOS and LOS alternatives differ only slightly except during the drier periods when OMR flow is slightly less negative under HOS than under LOS.

(3) Under wetter conditions all alternatives produce median OMR flows in the range targeted as protective in the Biological Opinions (more positive than -5,000 cfs, but see Modeled Impacts on Delta Smelt in Chapter 6). The use of NDD under high-flow conditions allows the HOS and LOS to avoid the extreme negative OMR values that occur under NAA because of the high south Delta export rates that are possible then.



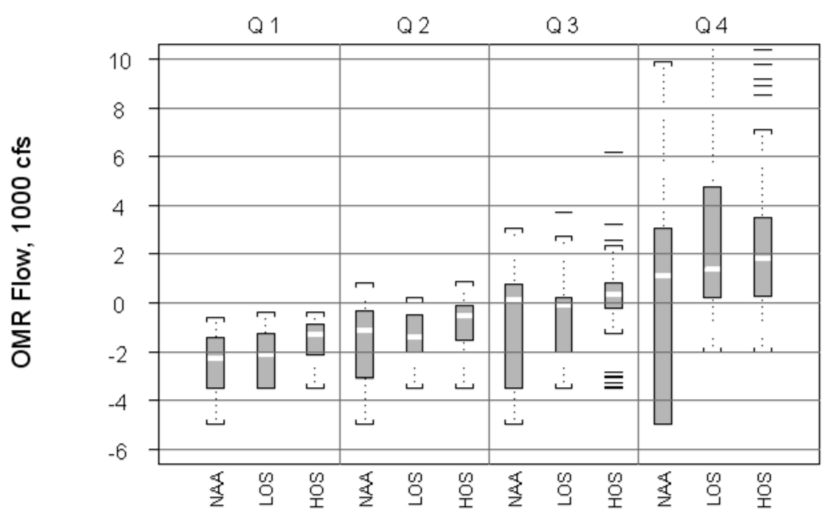


Figure 5.3. Values of OMR under the three alternatives for BDCP shown for quartiles of outflow under the No-Action Alternative. Boxes show first and third quartiles with the median as a white bar. The whiskers encompass points within 1.5 times the interquartile range, and the short lines are outliers. Top, period when adult longfin and delta smelt are vulnerable (December-March). Bottom, period when juvenile delta smelt are vulnerable (March-June)

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Thus, in summary, model results suggest that reverse flows in the south Delta become more positive under both LOS and HOS for all quartiles of outflow. These changes can be seen both in the frequency and in the distribution of flows in the two seasons of vulnerability and the four quartiles of NAA outflow. In wetter months the north Delta diversion does not fully replace south Delta exports until river inflows are relatively high, so that OMR remains negative in most months of smelt vulnerability. Changes in OMR during the period of vulnerability of young delta smelt are smaller than those during December-March because all alternatives are constrained by the Biological Opinions to a much higher baseline OMR flow.

Indirect effects

Net or tidally averaged flow on the lower San Joaquin River at Jersey Point is parameterized as QWEST. This flow can be negative (i.e., eastward), which is considered an indicator of flow conditions unfavorable to fish. Negative QWEST could alter the speed or path of fish migrating through the Delta, thereby prolonging their migrations or making them susceptible to adverse conditions in the Delta. No field estimates of indirect effects have been made and they are conceptually difficult because the biological effects are difficult to define and because the net flows in the lower San Joaquin River are small compared to tidal flows. Nevertheless, regulatory agencies, particularly the CDFW and the NMFS, have long expressed concern that negative values of QWEST due to project operations present fish with impediments to their effective migration.

The "east-west flow pattern in the San Joaquin River" referred to in the justification for CM#1 is apparently QWEST. QWEST is calculated in the Dayflow water balance program[59] as:

QSJR + QCSMR +QMOKE + QMISC + QXGEO - QEXPORTS - QMISDV - 0.65 (QGCD – QPREC),

i.e., the sum of inflows from San Joaquin River, eastside streams, and the Sacramento River via the Cross-Delta Channel and Georgiana Slough, minus south Delta exports, miscellaneous diversions in the Delta, and a fraction of the difference between precipitation and consumptive use within the Delta. However, for CALSIM modeling Delta consumptive use (QGCD), Delta precipitation (QPREC), and Delta miscellaneous diversions (QMISDV) are unavailable so the above equation simplifies to:

QWEST = QSJR + +QMOKE + QCSMR + QXGEO – QEXPORTS.

59. Details about the program can be found at http://www.water.ca.gov/dayflow.

QXGEO increases with Sacramento River flow and also depends on DCC gate operations. Specifically, QXGEO changes as 13.3% of Sacramento River flow with both DCC gates closed and 29.3% with both gates open (Dayflow documentation cited above). Sacramento River flow into the Delta will decrease by the amount diverted in the north Delta. Thus, among the flows controlled under BDCP, QWEST decreases by 100% of south Delta export flows and 13.3% or 29.3% of north Delta diversion flows depending on DCC gate positions.

There are many covered species of fish that migrate through or reside in the central Delta (Table 5.2). At least one of these species is present in the Delta during every month but August. Conditions in the central Delta are important for migratory species that spawn in the San Joaquin or Mokelumne Rivers because the entire population must pass through the central Delta. By contrast, only a fraction (unknown) of Sacramento fish enter the central Delta during migration. To cover the species that would be most affected by changes in flows in the San Joaquin River, we limit discussion to outmigrating salmonid juveniles (February-April) and upmigrating San Joaquin salmon (September-November).

Table 5.2. Species of fish covered by BDCP that reside within the Central Delta for specific life history stages and the season of sensitivity to changes in flow conditions due to project operations (from various sources)

Species and Life History Stage within the Delta	Timing
Sacramento and San Joaquin steelhead juveniles	February-April
Winter-run Chinook salmon juveniles	November-April
Spring-run Chinook salmon juveniles	March-May
Green sturgeon	November-December
Delta smelt adults	December-March
Delta smelt juveniles	April-June
Longfin smelt adults	December-February
Longfin juveniles	February-March
Upmigrating San Joaquin steelhead	September-April
Upmigrating spring-run Chinook salmon	March-August
Upmigrating winter-run Chinook salmon	January-May
Upmigrating fall-run salmon Chinook salmon	September-November

Juvenile salmon

The occasional high springtime flow requirements of HOS (to benefit longfin smelt) coincide with the smolt emigration season (February-April). In drier conditions (the drier two quartiles) there is very little difference between NAA and LOS (Figure 5.4). The occasional occurrence of high flow requirements in HOS produce some differences between LOS and HOS scenarios, but mostly in the second quartile when the high flows are more likely to be triggered than in the driest quartile. All project scenarios diverge from the NAA under the wetter scenarios as more water is diverted from the north Delta and substitutes for high south Delta exports (Figure 5.4). The several thousand cfs differences in wetter months are occurring against baseline flows in the realm of 20,000 cfs and greater, whereas the changes in flows in drier conditions are very small because limited North Delta diversion operations at low flows do not affect broad indices of Delta flow such as QWEST.

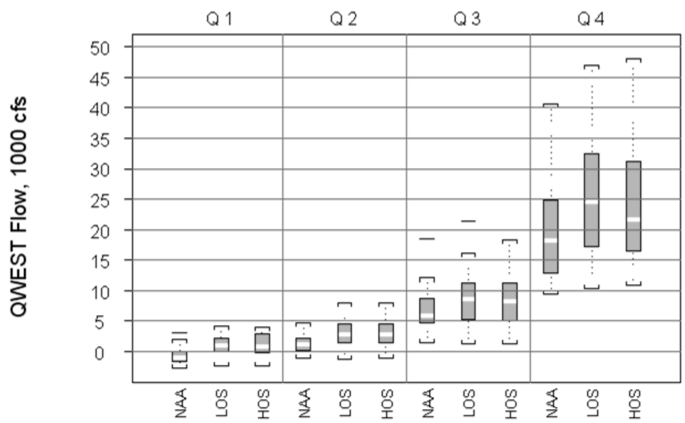


Figure 5.4. February-April QWEST values for NAA and 3 alternative operational scenarios, grouped by quartiles of outflow.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Adult San Joaquin fall-run salmon

Upmigrating salmon adults to the San Joaquin River pass through the south Delta and the lower San Joaquin River during September-November. In the fall there is very little difference among the alternatives that is not dwarfed by occasional high inflows due to flood releases or early winter storms (Figure 5.5). However, all alternatives show a general increase in QWEST compared to values for NAA because the use of the North Delta Diversion is much less restricted and can more often substitute for south Delta diversions that are often operating at maximum flow under NAA.

In summary, project scenarios have small effects on QWEST in any season; changes in QWEST are smaller than those in OMR because use of the North Delta diversion does not translate into direct increases in flow, as it can for OMR. This is true for both the spring and fall. The high flows in HOS produce increases in QWEST in months around median wetness.

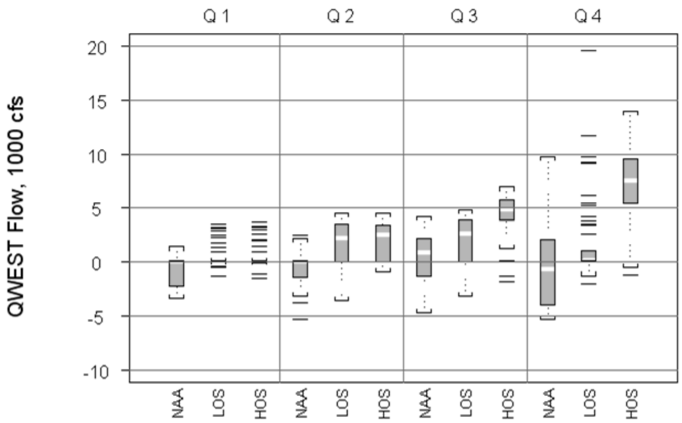


Figure 5.5. QWEST flows for the September-November season grouped by quartile of outflow.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

D. Conclusion

The analysis presented here demonstrates broad improvement in in-Delta conditions under BDCP, as measured by changes in OMR and QWEST. However, we reiterate our concerns over the likelihood that Delta flows would actually be managed in the manner prescribed by the modeling. Changes in the frequency of reverse flows and their magnitude were somewhat obscured by the high variability among years, even those with similar hydrology. Some of this variability is a consequence of carry-over storage and the specifics of operational rules that may be triggered by conditions in one year but not another even if hydrology is similar. In the context of this variability, the improvements in flow conditions during periods of vulnerability of the smelt and salmon species were modest.

In analyzing model results of the operational scenarios we were surprised to see benefits occurring under dry conditions. The restrictions on North Delta diversions limit its operations to times of substantial river flows, so its ability to substitute for south Delta diversions should be limited to times of high flow. In fact, at a broad range of intermediate flows, the north Delta diversion augmented south Delta exports, rather than substituting for them. Thus, improvements to in-Delta flow conditions happened mostly in the highest quartile of Delta outflow under NAA. The differences between flows under the LOS and HOS were generally rather small.

Chapter 6: Estimated Effects of BDCP Flows on Smelt

A. Introduction

This chapter takes the model projections for three scenarios discussed in Chapter 5 (NAA, HOS, and LOS) and uses various simple statistical models to estimate the potential effects of these flows on delta and longfin smelt. The principal flows of interest are:

- Winter and spring flows in Old and Middle Rivers, which affect adult and larval to juvenile delta smelt, respectively.
- Fall outflow, which may influence extent of habitat and therefore subsequent recruitment of delta smelt.
- Spring outflow, which has a statistical relationship with subsequent abundance of young-of-the-year longfin smelt.

We did not consider export effects on longfin smelt, for which there is no available statistical model and therefore no method to estimate losses without additional analysis beyond the scope of this review.

In making the calculations presented here we were constrained to use the CALSIM model output for the various flows by month and year. The concerns expressed in Chapter 5 apply here: *we do not believe that the system will actually be operated to obtain monthly patterns of flow like those in the* CALSIM *output*. This is particularly true in January and October, when wild swings in flows from one year to the next indicate a situation that would be very unlikely in the real system.

B. Direct Losses of Delta Smelt

Flows in Old and Middle River are related to salvage of delta smelt and other fish at the south Delta fish facilities. Annual salvage in turn is generally assumed to be a small fraction of entrainment losses, particularly for young (small) fish, because of various other losses attributed to export pumping, including predation in the waterways leading to the facilities and inefficient capture of delta smelt by the facilities.

Here we present estimates of export entrainment losses as a fraction of the population of delta smelt during the adult stage and the larval to early juvenile stage, only a small fraction of which is salvaged.[60] The calculations

60. Wim J. Kimmerer, *Losses of Sacramento River Chinook Salmon and Delta Smelt to Entrainment in Water Diversions in the Sacramento-San Joaquin Delta*, SAN FRANCISCO ESTUARY & WATERSHED SCI., June 2008, *available at* http://escholarship.org/uc/item/7v92h6fs.pdf [hereinafter Kimmerer 2008].

were based on results of a 2008 study by Kimmerer,[61] as amended for adult delta smelt by his 2011 study.[62] The general procedure was to determine a relationship for each of these two life stages between survival and flow variables that were available from CALSIM. Flows used were Old and Middle River flow (OMR) for adults, and net inflow (i.e., inflow less north Delta diversion flow, NDD) and export flow in the south Delta for larvae and juveniles combined.

We modeled the entire period of CALSIM analysis (WY 1922-2003) for the BDCP scenarios, and the historical period (1955-2003) for comparison. We calculated losses as described in Appendix C for the BDCP scenarios for both time periods, and for the historical period using Dayflow variables and OMR flows from USGS monitoring.

The principal assumptions were:

- The relationships used to calculate survival or recruitment accurately reflected the corresponding population parameters; that is, the confidence intervals of the predictions were assumed to include the true values of the population parameters with 95% probability. Note that these analyses by Kimmerer in 2008[63] and 2011[64] have not been repeated by any analysts, although a 2011 report by Miller[65] provided a detailed critique. This is rather worrisome, because both the BiOP and several published modeling studies rely on the accuracy of those analyses.[66]

---

61. *Id.*

62. Wim J. Kimmerer, Modeling delta smelt losses at the south Delta export facilities. SAN FRANCISCO ESTUARY & WATERSHED SCI., Apr. 2011, *available at* http://escholarship.org/uc/item/0rd2n5vb.pdf [hereinafter Kimmerer 2011].

63. Kimmerer 2008, *supra* note 60.

64. Kimmerer 2011, *supra* note 62.

65. William J. Miller, *Revisiting Assumptions That Underlie Estimates of Proportional Entrainment of Delta Smelt by State and Federal Water Diversions from the Sacramento-San Joaquin Delta*, SAN FRANCISCO ESTUARY & WATERSHED SCI., Apr. 2011, *available at* http://escholarship.org/uc/item/5941x1h8.pdf [hereinafter Miller 2011].

66. Mark N. Maunder & Richard B. Deriso, *A State-Space Multistage Life Cycle Model to Evaluate Population Impacts in the Presence of Density Dependence: Illustrated with Application to Delta Smelt* (Hyposmesus Transpacificus), 68 CAN. J. FISHERIES & AQUATIC SCI. 1285 (2011); Kenneth A. Rose, Wim J. Kimmerer, Karen P. Edwards & William A. Bennett, *Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San Francisco Estuary: I. Model Description and Baseline Results*, 142 TRANSACTIONS AM. FISHERIES SOC'Y 1238 (2013); Kenneth A. Rose, Wim J. Kimmerer, Karen P. Edwards & William A. Bennett, *Individual-Based Modeling of Delta Smelt Population Dynamics in the Upper San*

- Changes due to BDCP actions were cumulative such that each factor could be examined in isolation from the others, and its effect considered separately from the others.
- The only changes considered were those due to the entrainment effects of flow. Long-term changes in sea level, tidal prism, temperature, salinity, and physical configuration of the Delta were neglected, despite their likely influence on the exposure of the smelt population to export entrainment. Exceptions to this were the influences of these factors on flows modeled by CALSIM.
- The flow time-series produced by CALSIM accurately reflected the influence of the various changes (but note concerns expressed above and in previous chapters).
- The broad spatial distributions of delta smelt will not differ substantially from those existing when the above analyses were made. This may not be true if the fraction of the population in the north Delta is higher now and in the future than when the analyses were made.[67]

Losses of adult delta smelt were calculated as a linear function of OMR flows. Annual percent loss under each of the three scenarios was similar for the historical and modeled time periods (Figure 6.1). The estimated proportion of adults lost to entrainment was slightly lower for the NAA than for the historical period, reflecting overall lower export flows presumably because some operating rules were not in force during the historical period. The High- and Low-Outflow scenarios (HOS and LOS) both had proportional losses that were ~ half of those under the NAA, or a net change in loss of about 3%/year.

Losses of larval + juvenile smelt were modeled as a function of exports from the south Delta and inflow to the Delta less diversions from the North Delta facility. The patterns for young smelt were somewhat similar to those for adults but with larger differences among scenarios. The NAA had substantially lower losses than the historical condition over the historical period (Figure 6.2). Flows projected for both the HOS and LOS resulted in much lower losses than for the NAA, with losses under the HOS reduced to ~2%/year on average.

Francisco Estuary: II. *Alternative Baselines and Good Versus Bad Years*, 142 TRANSACTIONS AM. FISHERIES SOC'Y 1260 (2013).

67. Miller 2011, *supra* note 65; Kimmerer 2011, *supra* note 62.

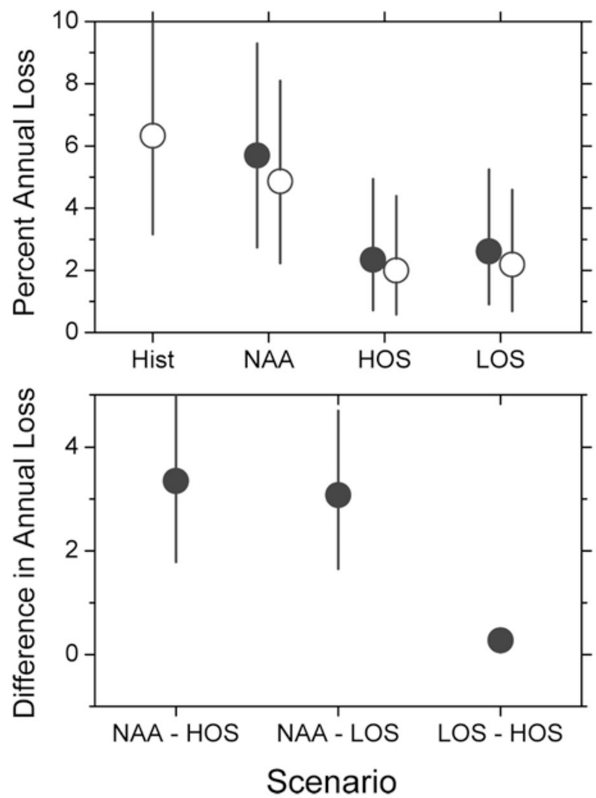


Figure 6.1. Annual percentage of adult delta smelt lost to export pumping for three scenarios and the historical time series. Symbols give means (see text) and error bars give the 95% confidence limit calculated as quantiles of the 1000 simulated samples of the respective distributions. Top panel, percent annual loss for 1922-2003 (filled symbols) and for 1980-2003 (open symbols) including the historical data. Bottom panel, differences between pairs of model scenarios.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

We combined results for adults and larvae + juveniles within each calendar year by first calculating the proportion of the population that would remain after 20 years at the mean values in Figures 6.1 and 6.2, then multiplying the proportions remaining to get the influence of these scenarios over both life stages. This is effectively a long-term survival percentage. These are not predictions, and are useful only for examining differences among scenarios. The resulting percentages were 38% for the HOS, 23% for the LOS, and 2% for the NAA (Table 6.1). In other words, the two scenarios with a north Delta diversion resulted in 19- and 11-fold increases in survival over a 20-year period.

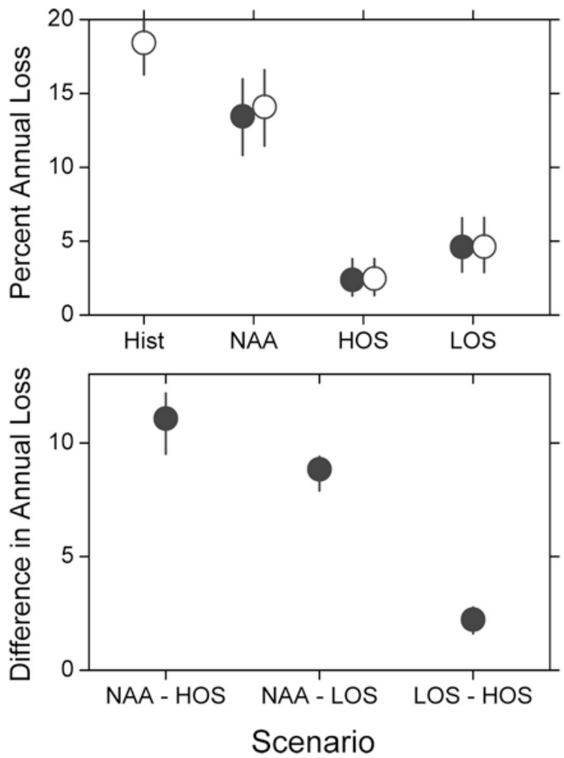


Figure 6.2. As in Figure 6.1 for losses of juvenile delta smelt.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

These numbers are highly uncertain, since the value for NAA is so small and variable (Table 6.1). There are indications that losses have been overestimated, especially given the potentially large subpopulation of young delta smelt that may be resident in the Cache Slough complex, where they are immune from effects of export pumping in the south Delta.[68] Using the upper confidence limits of the projected population size at the end of 20 years (i.e., the lower 95% confidence limits of the loss estimates) the ratios of population remaining after 20 years would have been 14 for HOS and 9 for LOS. These confidence limits do not account for any upward bias in loss estimates, and the loss estimates can and should be refined to reflect current understanding.

68. Miller 2011, *supra* note 65.

Nevertheless, the results of this analysis show a substantial improvement in long-term survival of delta smelt under HOS and to a lesser extent LOS, *provided the water projects are operated in ways that result in flows similar to those in the simulation*. Taken at face value the mean difference in losses between NAA and either of the other scenarios would have roughly sufficed to reverse the decline in delta smelt during the early 2000s.

Table 6.1. Percent of delta smelt population remaining for each of three BDCP scenarios after 20 years of losses at the rates estimated and shown in Figures 1 and 2. Values given with 95% confidence intervals.

	Adults	Juveniles	Combined
NAA	31 ± 22	6 ± 4	2 ± 2
HOS	62 ± 25	62 ± 15	38 ± 19
LOS	59 ± 25	39 ± 15	23 ± 13

C. Outflow Effects

Two time periods are considered for effects of changed outflow: fall for delta smelt and spring for longfin smelt. These effects are typically cast in terms of X2. For this analysis we calculated X2 from outflow as determined by CALSIM, using the monthly relationship from a 1995 study by Jassby,[69] as has been done for all previous analyses of relationships of X2 to abundance indices or habitat of fish.[70] CALSIM also produces X2 but it is for the previous month and is somewhat different from that used previously, particularly since it is said to account for sea-level rise and the effects of additional tidal prism due to marsh restoration. Since we were focused on the early long-term (ELT), we elected for now to neglect these considerations and use an X2 value that reflected the anticipated outflows in the same way as in the analyses of X2 effects on fish.

Fall X2 Effects on Delta Smelt

The USFWS Biological Opinion (BiOP) for delta smelt proposes to use X2 in the September-December period as a management tool. The principal

69. Alan D. Jassby et al., *Isohaline Position as a Habitat Indicator for Estuarine Populations*, 5 ECOLOGICAL APPLICATIONS 272 (1995) [hereinafter Jassby 1995].

70. *E.g.* Frederick Feyrer et al., *Multi-Decadal Trends for Three Declining Fish Species: Habitat Patterns and Mechanisms in the San Francisco Estuary, California*, U.S.A., 64 CAN. J. FISHERIES & AQUATIC SCI. 723 (2007) [hereinafter Feyrer 2007]; Wim J. Kimmerer et al., *Is the Response of Estuarine Nekton to Freshwater Flow in the San Francisco Estuary Explained by Variation in Habitat Volume?*, 32 ESTUARIES & COASTS 375 (2009) [hereinafter Kimmerer 2009].

basis for this action is the analyses of fall habitat indices by Feyrer et al. in 2007 and 2011,[71] and an unpublished analysis relating the Summer Townet index to the previous fall Midwater Trawl index and X2:

$$TNS_{y+1} \sim a + bMWT_y + cX2_y + \varepsilon_y \tag{6.1}$$

where TNS is the summer townet index, MWT the fall midwater trawl index, y is year, **ε** is error, a, b, and c are fitted parameters, and the time frame was restricted to after 1987 to account for the changes in the foodweb resulting from the introduction of the clam *Potamocorbula amurensis* (See Chapter 7 regarding food limitation of delta smelt).

This model assumes that the main effect of fall X2 on delta smelt is through a combination of survival and growth and therefore population reproduction in the following spring, resulting in effects on abundance in the following summer. Equation 6.1 is somewhat illogical in modeling TNS as an additive function of MWT and X2, and it is also strongly influenced by the data point from 1998, the wettest fall among those included in the analysis. Removing that point weakens that relationship somewhat, although it remains strong. Nevertheless, we fitted an alternative model:

$$\log(TNS_{y+1}) \sim a + b\log(MWT_y) + cX2_y + \varepsilon_y \tag{6.2}$$

which is more in keeping with the form of the other X2 models (Jassby et al. 1995). This model was fitted to all the data since 1987 using a robust regression method to allow for some over-dispersion in the residuals.[72] The regression coefficients were a=2.7, b= 0.62 ± 0.22, and c= 0.061 ± 0.55, R^2=0.68, and diagnostic plots revealed that this model was appropriate for the data (Figure 6.3). In particular 1998, and unusually wet year, did not have a strong influence on this relationship.

We extrapolated from this model to the BDCP scenarios using the CALSIM-modeled outflows. The target was the summer townet index, which we examined as a ratio to that predicted under NAA. In contrast to earlier analyses, we did not attempt to relate this to long-term population growth.

71. Feyrer 2007, *supra* note 70; Frederick Feyrer et al., *Modeling the Effects of Future Outflow on the Abiotic Habitat of an Imperiled Estuarine Fish*, 34 ESTUARIES & COASTS 120 (2011) [hereinafter Feyrer 2011].

72. W. N. VENABLES & B. N. RIPLEY, MODERN APPLIED STATISTICS WITH S 548 (4th ed. 2003) (function *rlm*).

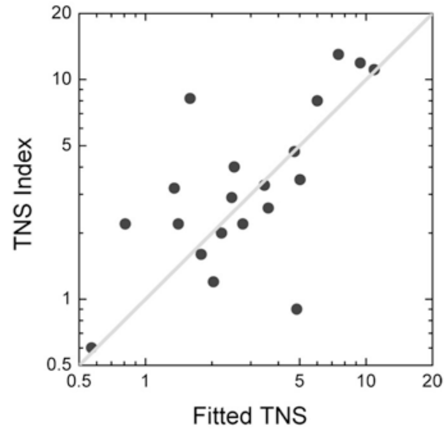


Figure 6.3. Fitted and measured summer townet index (TNS) with a 1:1 line. Values were fitted using Equation 6.2.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

The modeled monthly outflow values were converted to X2 according to the monthly equation in the 1995 study by Jassby et al.,[73] with the initial value (October 1921) set to the equilibrium X2 for the modeled flow. This was combined with historical monthly mean X2 values and all were averaged over September-December. Equation 6.2 was then used to predict the summer townet index from the mean fall midwater trawl index from 1988 to 2011 and X2 for the three scenarios.

Results showed HOS to have, on average, a slightly higher summer townet index than under NAA (Figure 6.4). The ratio of townet indices determined under HOS to that under NAA was 1.02, i.e., a 2% greater index under HOS, with 10th and 90th percentiles of 0.89 and 1.10 respectively. About a third of the values had lower confidence limits below zero, indicating low confidence that a real increase would be achieved under these conditions.

By contrast, the predicted ratio of townet index for LOS:NAA was about the same as that for HOS:NAA about half of the time, and the other half of the time it was much lower, with large confidence intervals related to the uncertainty in the prediction from the model. The calculated ratio had a median of 0.98 with 10th and 90th percentiles of 0.60 and 1.10. This peculiar pattern arose from the patterns of outflow in the CALSIM output (see Chapter 5). We have very low confidence that these patterns reflect how the system would really be operated, and therefore suggest these results be considered as conditional on proposed operational rules.

73. Jassby 1995, *supra* note 69.

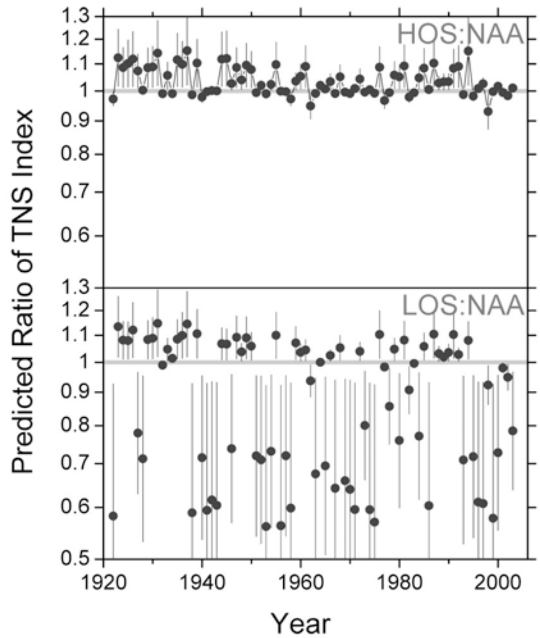


Figure 6.4. Ratios of predicted TNS index by year from HOS (top) and LOS (bottom) to those from NAA.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Spring Outflow/X2 Effects on Longfin Smelt

Longfin smelt has the strongest relationship of abundance index to X2 of any fish (Jassby et al. 1995). The index for a given level of X2 has declined, but the response to flow has not changed. We updated the latest published version of this relationship[74] by adding two step changes in time: one in 1987-1988 corresponding to the spread of the clam P*otamocorbula amurensis*, and the other in 2003-2004, the POD decline.[75] The statistical model used was:

$$\log_{10}(LFS_y) = a_y + bX2_y + \varepsilon_y \tag{6.3}$$

Where LFS is the annual index of longfin smelt abundance from the fall midwater trawl survey, y is year, X2 is monthly values averaged over either

74. Kimmerer 2009, *supra* note 70.

75. James R. Thomson et al., *Bayesian Change-Point Analysis of Abundance Trends for Pelagic Fishes in the Upper San Francisco Estuary*, 20 ECOLOGICAL APPLICATIONS 1431 (2010).

January-June[76] or March-May, and ε is error. Fitting parameters are *a*, which takes one of three values by year group, and *b*, the slope of the X2 relationship.

The resulting relationship (Figure 6.5) shows both the effect of X2 and the two step-changes in abundance index. Diagnostic statistics showed that the model was appropriate. Since we were interested in the difference between the two alternative flow scenarios and NAA, the only parameter that concerned us here was *b*, which had a value of $-0.054 \pm 0.005\ km^{-1}$, essentially identical to previously published values. Averaging X2 over March-May gave a slope of $-0.049 \pm 0.005\ km^{-1}$, and the fit was slightly inferior to that of the January-June model.

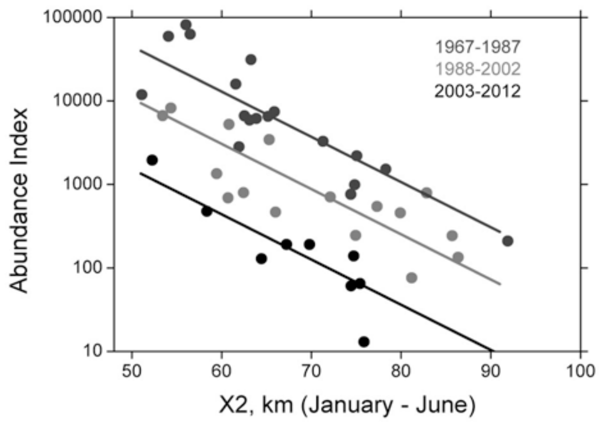


Figure 6.5. Abundance index of longfin smelt vs. X2 averaged over January-June, with step changes between 1987 and 1988 and between 2002 and 2003. Colors of points and lines indicate the time period.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

The months selected in the original analysis were based on the assumption that the (unknown) X2 mechanism operated during early life history of longfin smelt, which smelt experts linked to this period. Autocorrelation in the X2 values through months means that statistical analysis provides little guidance for improving the selection of months. A better understanding of the mechanism(s) underlying the relationship would probably allow this period to be narrowed and focused, but for now there is little basis for selecting a narrower period for averaging X2.

The predictions from the above model were then applied to the X2 values calculated from the CALSIM projections of outflow for the 82-year

76. *See* Jassby 1995, *supra* note 69.

period. We did not attempt to propagate prediction error because it is small compared to variability in outflow. Applying the January-June value for the three selected scenarios resulted in scant differences in predicted abundance indices (Figure 6.6). The median $\log_{10}$ ratio of indices for HOS:NAA was 1.00 (mean 1.05) with 10th and 90th percentiles of 0.91 and 1.27. Corresponding values for LOS:NAA were median 0.92 (mean 0.92) and percentiles of 0.83 and 1.00.

Thus, changes in outflow resulting from the CALSIM projections of spring outflow were small, particularly on the scale of the high variability with X2. HOS provided a minuscule increase in the mean but the median did not change from NAA, indicating that half of the years had higher, and half lower, values under HOS than under NAA. LOS gave values that were ~8% lower than those under NAA.

Although it would be desirable to link such calculations to a population-dynamics model, no such model is available; furthermore, previous analyses have shown that abundance of longfin smelt is highly predictable from X2 and, more recently, groups of years as done above. This does not mean that stock-recruit relationships are unimportant; an alternative analysis models a recruitment index, the log of the ratio of MWT to the MWT value 2 years earlier, as a function of X2.[77] However, it is unlikely this analysis would indicate a stronger effect of X2 on longfin smelt under BDCP.

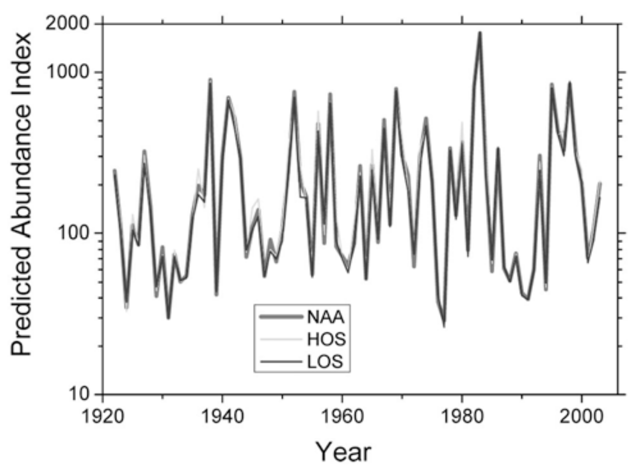


Figure 6.6. Predicted abundance from the model in Figure 6.3 for the three BDCP scenarios. The intercept for the third time period (2003-2012) was used to calculate these indices.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

77. *See, e.g.*, the work of Nobriga and Rosenfield.

D. Conclusions

The modeled flow changes under BDCP have mixed effects on the two smelt species. For delta smelt, changes in flow in the south Delta had a marked effect on survival of both adult and young smelt, such that gains of several percent a year would be forecasted for the difference between the NAA and the two with-project alternatives. Effects of outflow on delta smelt were small for HOS compared with NAA, while projections under LOS showed about half the time a marked reduction in predicted summer abundance index compared to NAA. Effects of spring outflow on longfin smelt were not very large.

The results for delta smelt were somewhat surprising, since food supply is clearly an important limitation (Chapter 7) and more likely implicated in the decline than export losses. We nevertheless stand by these results subject to the following contingencies:

- The water projects will be operated to achieve similar flow patterns as in the CALSIM output we used in our analysis.
- Future re-analyses of the influence of export pumping on delta smelt are used to refine these estimates.
- Effects of increasing temperature, introductions of quagga or zebra mussels or other high-impact species, changing flow-X2 relationship, rising sea level, and catastrophic inundation of Delta islands do not materially alter the trajectory of delta smelt.

The last point is presented almost facetiously—things will change, in some ways we can predict and other ways we cannot. The BDCP takes account of some of these changes but others are just as likely over the time frame of the project and should be accounted for (Chapter 8). Nevertheless, at present we lack the capability to include these factors in a more thorough analysis, but believe it should be done.

Longfin smelt, by contrast, are unlikely to be much affected by BDCP. The anticipated changes in outflow are rather minor, and the flows needed for substantial changes in longfin smelt abundance are likely too great to be practically achieved.

Chapter 7: Likely Response of Listed Fishes to Physical Habitat Restoration

A. Introduction

This Chapter focuses on the proposed restoration of physical habitat in the Delta and Suisun Marsh. Because of time constraints we have focused on the potential benefits of floodplain and marsh restoration to delta and longfin smelt. These benefits are postulated to occur through expanded physical habitat for the fish, or through export of food from the restored areas to smelt habitat.

B. Summary of Assessment

The BDCP proposes to restore 55,000 acres of subtidal to intertidal habitat[78] of which 20,600 acres is to be allocated among various Restoration Opportunity Areas (ROAs) in the Delta and Suisun Marsh and the remainder to be allocated later. If completed this restoration will substantially increase the inundated portion of the Plan Area; for example if all 7,000 acres assigned to Suisun Marsh were restored it would roughly triple the area exposed to tidal action.

The ROA's include Suisun Marsh, Cache Slough, and the eastern, southern, and western Delta. The documentation is unclear on the depth profiles of these areas and for calculations below we have assumed that about half of each will be intertidal and the remainder subtidal with a mean depth of 2 meters. The document lists the aquatic and terrestrial species expected to benefit from these actions, but here we focus only on their likely effects on the two smelt species.

Our results to date lead to the following preliminary conclusions:

- Delta and longfin smelt are usually food limited, meaning that population levels would rise if there were more zooplankton in their rearing areas. This limitation is probably stronger in spring-fall than in winter.
- The BDCP is overly optimistic about the likely benefits of tidal marsh restoration to the smelt species, particularly the extent of food production.
- A review of the literature suggests that tidal marshes may either import or export phytoplankton and zooplankton.
- Under highly favorable assumptions about production and export of plankton, restored tidal marshes could make at most a modest contribution to extant plankton production.
- The subpopulation of delta smelt that inhabit the Cache Slough complex through summer may benefit from additional physical space in that area. The same could be true in Suisun Marsh although current use by smelts is low.
- The high level of uncertainty about outcomes points to the use of moderate- to large-scale experimental restoration projects to

78. "Habitat" means the location and conditions in which a population of a species lives; here we follow the BDCP document in using the term to mean a physical space. We likewise use "restore" to mean to prepare that space for the potential occupation of one or more species, irrespective of the previous condition of the space.

determine whether the proposed restoration will achieve the food-production goals and, if so, how to design them optimally.

C. Marsh Restoration

Review of Conceptual Basis

The BDCP anticipates many benefits to delta and longfin smelt. Although the documentation is unclear on the expected magnitudes of these benefits, it is uniformly optimistic that they will contribute substantially to recovery of the species. Here we focus on two potential benefits to the smelts from the restoration of tidal habitats. First, the restored habitats are expected to provide a food supply that will enhance the food supply available to the smelts. Second, the restored habitats are expected to provide additional physical space, resulting in an increase in smelt abundance. Neither of these proposed benefits is well developed in the documentation, and the literature cited seems to have been selected to support the claims made. The BDCP documentation furthermore contains factual errors and misinterpretations that cast doubt upon the projections that are made, however qualitative. We therefore conducted a reasonably thorough analysis of these specific claims, within the constraints of time available.

The first outcome requires two conditions: 1) that the smelt populations are currently food-limited, meaning that an increase in concentration of food organisms would result in a higher abundance of smelt; and 2) that the restored marshes will produce and export enough food organisms to make a difference to the population status of the smelts.

BDCP Appendix 5E uses "prod-acres" to index the expected productivity of phytoplankton in the restored areas. However, this index is conceptually flawed in two ways. First, it uses an estimate of growth rate rather than production of phytoplankton, which is the product of growth rate and biomass. Second, it assumes implicitly that all phytoplankton growth is available as food for the zooplankton consumed by the smelt species, but analyses published on the San Francisco Estuary and elsewhere show that most of the production is consumed by benthos and by microzooplankton such as ciliates.[79]

79. *See, e.g.*, Cary B. Lopez et al., *Ecological Values of Shallow-Water Habitats: Implications for the Restoration of Disturbed Ecosystems*, 9 ECOSYSTEMS 422 (2010) [hereinafter Lopez 2010]; Lisa V. Lucas & Janet K. Thompson, *Changing Restoration Rules: Exotic Bivalves Interact with Residence Time and Depth to Control Phytoplankton Productivity*, ECOSPHERE, Dec. 2012, http://www.esajournals.org/doi/pdf/10.1890/ES12-00251.1 [hereinafter Lucas & Thompson 2012]; Wim J. Kimmerer & Janet K. Thompson, *Phytoplankton Growth Balanced by Clam and Zooplankton Grazing and Net Transport into the Low-Salinity Zone of the San Francisco Estuary*, ESTUARIES & COASTS, Jan. 7, 2014, http://link.springer.com/content/pdf/10.1007%2Fs12237-013-9753-6.pdf [hereinafter Kimmerer & Thompson 2014].

The smelt species are expected to occupy some of the restored habitats. This may provide benefits in the form of increased opportunities for individual fish to find suitable conditions such as spawning substrate, food patches, or shelter from predators. A potential benefit is to diversify the locations in which the smelt species occur, in an attempt to increase resilience of the populations to local perturbations such as high-temperature periods or toxic spills.

Analysis of Components

For effects of food production and export we assessed the evidence for food limitation of the smelt populations, and for the amount of food (zooplankton) that restored marshes would export to waters where the smelt species occur. For physical habitat we examined current patterns of occurrence to determine the likely effect of additional physical habitat on the smelt species.

We do not address other potential indirect impacts of marsh restoration, or interactions with other proposed projects. Restoration of extensive areas of marsh will increase the tidal prism in the restored area. This will affect tidal currents and elevations both locally and all the way to Carquinez Strait, and therefore affect salinity penetration and the movement of sediments. The effects on salinity have been included in the modeling presented in BDCP documents, but we did not review this. The U.S. Army Corps of Engineers has proposed a project, now on hold, to deepen the Sacramento Deep-Water Ship Channel, which is currently an important part of the habitat of delta smelt. This and other non-BDCP projects should be taken into account when considering impacts of BDCP.

Are Smelt Species Food Limited?

What is the evidence for and against food limitation in delta and longfin smelt? By food limitation we mean a situation in which an increase in concentration of food organisms would result in a higher abundance of smelt. This does not require that all or even most fish have depressed growth or reproductive rates, only that at least some of them do. Substantial food limitation would require the following to be true:

(1) The density of food organisms is too low to support the maximum growth rate of the fish.
(2) Therefore some fish are in poorer condition or grow more slowly than under food satiation.
(3) Either or both of the following:
    a. Survival over a life stage depends on condition and therefore food supply.

b. Reproductive rate of an adult varies with growth rate during development through its effect on maturity or total eggs per female.

(4) Higher reproduction leads to a larger population, all else being equal. We assume this condition must be true as a straightforward consequence of population dynamics.

Food limitation could occur at one or more life stages, which may occupy different parts of the estuary. During spawning and early life delta smelt are mostly in freshwater. During the late larval stage (~July) until the pre-spawning migration in December, part of the population is in the low-salinity zone (LSZ, salinity ~0.5-5), and part is in the Cache Slough-Liberty Island complex in the North Delta.[80] Longfin smelt also spawn in freshwater but move earlier and further seaward.[81] We refer to fish between metamorphosis from the larval stage to their spawning migration as juveniles (i.e., including all fish caught in the fall midwater trawl survey). Both smelt species consume available plankton in their habitat, with the size of prey related to that of the fish.

Food limitation is surprisingly difficult to demonstrate in a fish population. Nearly all populations must be food limited to some degree. However, food limitation of individual fish can be difficult to detect. The prey and the fish are spatially patchy and temporally variable, so the degree of food limitation is sporadic and patchy. Great differences among individuals in feeding success result in differences in growth and survival, such that the survivors are those that have been well fed. Feeding success also interacts with other influences such as predation risk and physiological stress.

The analysis of food limitation relies on a variety of direct and indirect evidence (details in Appendix D). Some studies suggest food limitation inferred from correlations of abundance or length with measures of food availability, indices of gut fullness and physiological condition of field-caught smelt, and laboratory-derived estimates of feeding rate in relation to food concentration. A few other studies do not support food limitation in these species. However, the weight of evidence suggests that food is limiting the populations of both smelt species.

80. Ted Sommer et al., *The Spawning Migration of Delta Smelt in the Upper San Francisco Estuary*, SAN FRANCISCO ESTUARY & WATERSHED SCI., June 2011, http://escholarship.org/uc/item/86m0g5sz.pdf.

81. Jonathan A. Rosenfield & Randall D. Baxter, *Population Dynamics and Distribution Patterns of Longfin Smelt in the San Francisco Estuary*, 136 TRANSACTIONS AM. FISHERIES SOC'Y 1577 (2007); Kimmerer 2009, *supra* note [Chapter 6 fn 11].

Export of Food from Shallow Restored Areas

One purported benefit to smelts of restored shallow areas is that elevated food production in these areas will be exported as a subsidy to open waters where the smelts are abundant. The implicit conceptual model is that these shallow areas will produce an excess of phytoplankton and zooplankton that will then be exported by stream flow or tidal currents. A subsidy of phytoplankton could stimulate zooplankton production in the open waters, since the zooplankton in this estuary are chronically food-limited in their growth or reproduction.[82] However, grazing by clams is likely to prevent such a subsidy from having much effect on zooplankton production. The alternative subsidy is that of zooplankton grown within the restored areas, including larger forms such as mysids that are consumed by juvenile longfin smelt and adult delta smelt.

The magnitude of any subsidy depends also on the transport process. Where the transport is mediated by tidally driven currents, the subsidy will be related to the tidal exchange and the difference in biomass between the restored area and the open water. Where it is mediated by river flow, the subsidy will depend on the net flow and the biomass in the restored area.

Here we examine the literature on subsidies from marshes, use a simple model to estimate the magnitude of such a subsidy of either phytoplankton or zooplankton, and estimate the proportional flux from the Suisun Marsh to Suisun Bay using output from a particle-tracking model as a measure of the extant subsidy. Our conclusions are:

- The literature does not support a confident assertion that marshes will subsidize zooplankton of the open waters.
- Calculated subsidies of phytoplankton and zooplankton are modest under optimistic assumptions about in-marsh production and design of restoration sites.
- A subsidy of zooplankton from Suisun Marsh to Grizzly Bay cannot be very large under current conditions, and is unlikely to be much larger with the proposed extent of restoration.

Do shallow areas export phytoplankton or zooplankton?

Marshes can be major producers of organic matter because of their extensive vegetated surface exposed to sunlight, shallow waters leading to

82. Anke B. Müller-Solger et al., *Nutritional Quality of Food Resources For Zooplankton* (Daphnia) *in a Tidal Freshwater System* (*Sacramento-San Joaquin River Delta*), 47 LIMNOLOGY & OCEANOGRAPHY 1468 (2002); Wim J. Kimmerer et al., *Chronic Food Limitation of Egg Production in Populations of Copepods of the Genus* Acartia *in the San Francisco Estuary*, 28 ESTUARIES 541 (2005).

light penetration through all or most of the water column, and the continual supply of nutrients from the open waters and from land (Figure 7.1). This appears to be true even for recently restored marshes.[83] Over the long term, mass must balance, so production in excess of respiration by organisms within the marsh must be either buried or exported as organic matter or organisms to adjacent estuarine waters.

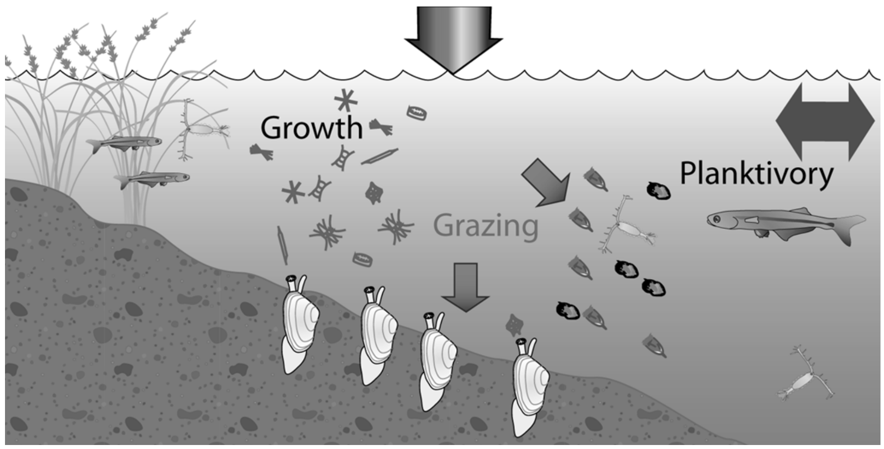


Figure 7.1. Conceptual model of the production of food for pelagic fish in a low-order tidal marsh channel. Because the water is shallow (and may be clearer than in adjacent channels) light penetration is good and growth of phytoplankton and benthic microalgae is high. Losses of phytoplankton occur through benthic grazing and by pelagic grazing, chiefly by microzooplankton but also by larger zooplankton such as copepods that can be consumed by fish. Benthic grazers filter a certain volume of water every day, so the shallower the water the more intensive the grazing on the plankton of the marsh. Small planktivorous fish such as Mississippi silversides seek shelter in the shallowest and vegetated areas; thus consumption of zooplankton is also more focused and more selective for larger organisms in shallow water. Tidal exchange of water with the adjacent higher-order (larger) channel transports nutrients, organic matter, and plankton between marsh and channel, but the direction of transport for zooplankton may be in or out of the marsh depending on the outcomes of the various production and consumption processes.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

83. Emily R. Howe & Charles A. Simenstad, *Isotopic Determination of Food Web Origins in Restoring and Ancient Estuarine Wetlands Of The San Francisco Bay And Delta*, 34 ESTUARIES & COASTS 597 (2011) [hereinafter Howe & Simenstad 2011].

Export of organic matter from marshes to adjacent estuarine waters was first considered as the "outwelling hypothesis."[84] This hypothesis holds that the export of labile organic matter provides an important subsidy to nourish adjacent waters of the estuary or continental shelf.

The outwelling hypothesis originated in studies of extensive, rich marshes on the east and Gulf coasts, but even there, quantitative demonstrations of its importance to estuarine or coastal foodwebs were few.[85] Much of the difficulty arises from the technical challenge of measuring a small net flux in a large tidal signal with high variability.[86] In addition, dissolved and particulate organic matter produced by rooted vegetation can be highly refractory and therefore largely unavailable to estuarine pelagic foodwebs, which are usually fueled mainly by phytoplankton.[87]

Marshes can be sites of high productivity by benthic or planktonic microalgae because they are shallow, so waters are well lit. Therefore a marsh could export organic matter as living phytoplankton. However, the extent of this export depends on consumption within the marsh, including consumption of phytoplankton by benthic grazers in shallow waters.[88] Often overlooked in attempts at a mass-balance of phytoplankton is the high rate of consumption by microzooplankton, which typically consume about 60% of the production by phytoplankton in estuaries.[89] Thus, the production actually available for consumption by mesozooplankton, and for export, is

84. Eugene P. Odum, *The Status of Three Ecosystem-Level Hypotheses Regarding Salt Marsh Estuaries: Tidal Subsidy, Outwelling and Detritus-Based Food Chain*, *in* ESTUARINE PERSPECTIVES 485 (Victor S. Kennedy ed., 1980); Scott W. Nixon, *Between Coastal Marshes and Coastal Waters - A Review of Twenty Years of Speculation and Research on the Role of Salt Marshes in Estuarine Productivity and Water Chemistry*, *in* 11 MARINE SCIENCE, ESTUARINE AND WETLAND PROCESSES: WITH EMPHASIS ON MODELING 437 (Peter Hamilton & Keith B. Macdonald eds., 1980).

85. R. Dame et al., *The Outwelling Hypothesis and North Inlet, South Carolina*, 33 MARINE ECOLOGY PROGRESS SERIES 217 (1986).

86. *Id.*

87. William V. Sobczak et al., *Bioavailability of Organic Matter in a Highly Disturbed Estuary: The Role of Detrital and Algal Resources*, 99 PROCEEDINGS NAT'L ACAD. SCI. UNITED STATES AM. 8101 (2002); William V. Sobczak et al., *Detritus Fuels Ecosystem Metabolism but Not Metazoan Food Webs in San Francisco Estuary's Freshwater Delta*, 28 ESTUARIES 124 (2005).

88. *See* Cary B. Lopez et al., *Ecological Values of Shallow-Water Habitats: Implications for the Restoration of Disturbed Ecosystems*, 9 ECOSYSTEMS 422 (2006) (describing the extent of export for flooded islands in the Delta).

89. Albert Calbet & Michael R. Landry, *Phytoplankton Growth, Microzooplankton Grazing, and Carbon Cycling in Marine Systems*, 49 LIMNOLOGY & OCEANOGRAPHY 51 (2004); Joanna K. York et al., *Microzooplankton Grazing in Green Water—Results from Two Contrasting Estuaries*, 34 ESTUARIES & COASTS 373 (2011).

considerably lower than would be expected from estimates of primary production.

For zooplankton the magnitude and direction of the flux depends on behavior and on size- and taxon-specific patterns of mortality. In particular, visual predation by fish can exert strong control on the size distributions, and therefore species distributions, of zooplankton.[90] Vertical movements of zooplankton and hatching or settlement of larvae can lead to spatial patterns of abundance that do not reflect tidal transport.[91] Consumption of zooplankton by small fish that seek food and shelter in shallow areas can reduce zooplankton abundance near shore, and shift the size distribution toward smaller forms, in lakes,[92] lagoons,[93] and marshes.[94] The outcome can be net fluxes into shallow areas,[95] and marshes can be simultaneously sinks for copepods and areas of aggregation for bottom-oriented larvae.[96]

Thus, marshes may act either as net sources or sinks for plankton in the adjacent waters, depending on the availability of habitat for small fish and the degree of colonization by benthic grazers such as clams. The exact details of the exchange processes depend on the physical configuration of the marsh including permanence of inundation,[97] residence time of the

90. John Langdon Brooks & Stanley I. Dodson, *Predation, Body Size, and Composition of Plankton*, 150 SCIENCE 28 (1965).

91. Dorian S. Houser & Dennis M. Allen, *Zooplankton Dynamics in an Intertidal Salt-Marsh Basin*, 19 ESTUARIES 659 (1996).

92. Sandra Brucet et al., *Zooplankton Structure and Dynamics in Permanent and Temporary Mediterranean Salt Marshes: Taxon-Based and Size-Based Approaches*, 162 ARCHIV FUR HYDROBIOLOGIE 535 (2005), http://www.researchgate.net/publication/230707962_Zooplankton_structure_and_dynamics_in_permanent_and_temporary_Mediterrane_salt_marshes_taxon-based_and_size-based_approaches/file/79e415124b560db779.pdf [hereinafter Brucet 2005]; Sandra Brucet et al., *Factors Influencing Zooplankton Size Structure at Contrasting Temperatures in Coastal Shallow Lakes: Implications for Effects of Climate Change*, 55 LIMNOLOGY & OCEANOGRAPHY 1697 (2010).

93. Anna Badosa et al., *Nutrients and Zooplankton Composition and Dynamics in Relation to the Hydrological Pattern in a Confined Mediterranean Salt Marsh (NE Iberian Peninsula)*, 66 ESTUARINE COASTAL & SHELF SCI. 513 (2006).

94. Matthew J. Cooper et al., *Edge Effects on Abiotic Conditions, Zooplankton, Macroinvertebrates, and Larval Fishes in Great Lakes Fringing Marshes*, 38 J. GREAT LAKES RES. 142 (2012).

95. Carlson 1978 W. J. Kimmerer & A. D. McKinnon, *Zooplankton in a Marine Bay. III. Evidence for Influence of Vertebrate Predation on Distributions of Two Common Copepods*, 53 MARINE ECOLOGY PROGRESS SERIES 21 (1989).

96. Debashish Mazumder et al., *Zooplankton Inputs and Outputs in the Saltmarsh at Towra Point, Australia*, 17 WETLANDS ECOLOGY & MGMT. 225 (2009).

97. Brucet 2005, *supra* note 92.

water,[98] and the biological composition, i.e., the kinds and abundance of producers and consumers within the marsh including transient organisms.[99] If the excess organic matter is being transported by fish as in some east coast marshes,[100] little benefit would accrue to planktivorous fish in the open waters such as the smelts.

Few of these aspects have been examined in marshes of the San Francisco Estuary. Long-term studies of Suisun Marsh have revealed a lot about fish assemblages[101] and medusae and some zooplankton,[102] and some detailed studies of exchange processes have been undertaken.[103] Zooplankton abundance is highest in small sloughs of long residence time.[104]

Foodwebs in diverse marshes of the San Francisco Estuary are supported more by local plant production than by estuarine phytoplankton.[105]

This implies a division of organic-matter sources between those supporting littoral and marsh foodwebs and those supporting pelagic foodwebs.[106]

---

98. Lisa V. Lucas & Janet K. Thompson, *Changing Restoration Rules: Exotic Bivalves Interact with Residence Time and Depth to Control Phytoplankton Productivity*, ECOSPHERE, Dec. 2012, http://www.esajournals.org/doi/pdf/10.1890/ES12-00251.1.

99. R. T. Kneib, *The Role of Tidal Marshes in the Ecology of Estuarine Nekton*, 35 OCEANOGRAPHY & MARINE BIOLOGY ANN. REV. 163 (1997).

100. *Id.*

101. *E.g.* Scott A. Matern et al., *Native and Alien Fishes in a California Estuarine Marsh: Twenty-One Years of Changing Assemblages*, 131 TRANSACTIONS AM. FISHERIES SOC'Y 797 (2002); Frederick Feyrer et al., *Dietary Shifts in a Stressed Fish Assemblage: Consequences of a Bivalve Invasion in the San Francisco Estuary*, 67 ENVTL. BIOLOGY FISHES 277 (2003).

102. Alpa P. Wintzer et al., *Life History and Population Dynamics of* Moerisia Sp.*, a Non-Native Hydrozoan, in the Upper San Francisco Estuary* (U.S.A.), 94 ESTUARINE COASTAL & SHELF SCI. 48 (2011); Mariah H. Meek et al., *Genetic Diversity and Reproductive Mode in Two Non-Native Hydromedusae,* Maeotias Marginata *and* Moerisia Sp.*, in the Upper San Francisco Estuary, California*, 15 BIOLOGICAL INVASIONS 199 (2013).

103. Steven D. Culberson et al., *Sensitivity of Larval Fish Transport to Location, Timing, and Behavior Using a Particle Tracking Model in Suisun Marsh, California*, *in* EARLY LIFE HISTORY OF FISHES IN THE SAN FRANCISCO ESTUARY AND WATERSHED 257 (Frederick Feyrer, Larry R. Brown, Randall L. Brown & James J. Orsi eds., 2004).

104. Personal communication with Peter B. Moyle, Professor in Dept. of Wildlife, Fish, and Conservation Biology & Assoc. Dir. of the Center for Watershed Sciences, University of California, Davis.

105. Emily R. Howe & Charles A. Simenstad, *Restoration Trajectories and Food Web Linkages in San Francisco Bays Estuarine Marshes: A Manipulative Translocation Experiment*, 351 MARINE ECOLOGY PROGRESS SERIES 65 (2007); Howe & Simenstad 2011, *supra* note 83.

In 2010, Lehman et al. estimated the fluxes of various substances in and out of Liberty Island, a flooded island in the Cache Slough complex in the northern Delta.[107] They found large seasonal shifts in the magnitude and direction of fluxes.[108] In particular, seasonal chlorophyll flux was into Liberty Island in spring and out in fall, based on point measurements, and into the island in all seasons but more so in spring and summer, based on the continuous measurements.[109] Fluxes of copepods were out during spring and fall, and in during summer, based on a total of six sampling days.[110] Although the 2010 study by Lehman et al. linked fluxes into Liberty Island with storage within the island, it was equally likely to have been a function of consumption, particularly since high inward fluxes of chlorophyll and zooplankton occurred in summer when biological activity would have been high.

A few other marshes and restoration sites in the estuary have been investigated for their potential links to open waters. The South Bay Salt Ponds, which began to be reconnected to the tidal action of the Bay in 2006, are highly productive and may export organic matter to nearby estuarine waters.[111] A marsh at China Camp in San Pablo Bay was a net sink for mysids, probably through predation within the marsh.[112]

Calculated Subsidies

Here we assume that the restored areas will actually produce an excess of phytoplankton or zooplankton over adjacent waters, and ask what additional level of food availability to the smelt would result. This is based on a very simple model using data from IEP monitoring, described in detail in Appendix E (See Figure 7.2). The basis of this model is to calculate the subsidy based on high levels of biomass and growth rate in a 2,500-acre marsh that is closely connected to smelt habitat and has an optimum rate of

106. Lenny F. Grimaldo et al., *Dietary Segregation of Pelagic and Littoral Fish Assemblages in a Highly Modified Tidal Freshwater Estuary*, 1 MARINE & COASTAL FISHERIES: DYNAMICS, MGMT., & ECOSYSTEM SCI. 200 (2009).

107. P. W. Lehman et al., *The Freshwater Tidal Wetland Liberty Island, CA Was Both a Source and Sink of Inorganic and Organic Material to the San Francisco Estuary*, 44 AQUATIC ECOLOGY 359 (2010).

108. *Id.*

109. *Id.*

110. *Id.*

111. Julien Thebault et al., *Primary Production and Carrying Capacity of Former Salt Ponds After Reconnection to San Francisco Bay*, 28 WETLANDS 841 (2008).

112. Amy F. Dean et al., *Marshes As Sources or Sinks of an Estuarine Mysid: Demographic Patterns and Tidal Flux of* Neomysis Kadiakensis *at China Camp Marsh, San Francisco Estuary*, 63 ESTUARINE, COASTAL & SHELF SCI. 1 (2005).

exchange with the open water. We assume smelt habitat is represented by the Low-Salinity Zone (LSZ), which has a volume of about 0.5 km^3.

A subsidy is maximized by a large marsh close to the smelt habitat, with tidal exchange close to but not above the net population growth rate of the plankton (Figure 7.3). The subsidy is degraded or even reversed by consumption (clams, planktivorous fish) within the marsh. Water depth may have a positive or negative effect on the subsidy.

The simple model in Appendix E shows that under an extremely favorable set of conditions both within and outside of the marsh, a modest subsidy of phytoplankton is possible. Phytoplankton input to the LSZ could amount to 16%/day, or about half of the daily net production in the LSZ. However, smelt species do not eat phytoplankton, and the conversion of phytoplankton to zooplankton depends on factors in the open water such as grazing. The direct subsidy of zooplankton would be about 3%/day, also under unrealistically ideal conditions. Although this is not negligible, any reduction in this value would effectively eliminate the subsidy to open water.

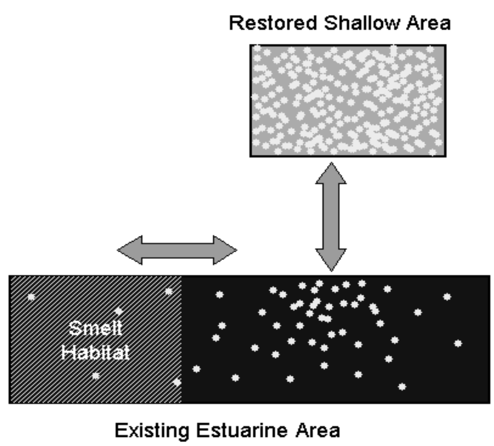


Figure 7.2. Schematic diagram of a subsidy of zooplankton (yellow circles) from a restored tidal marsh or other shallow area to an existing estuarine area. Zooplankton move by dispersion (double-sided arrows) between the restored and existing areas, and within the existing area from the outlet of the restored area to other regions of the estuary including smelt habitat. Advection may alter the flow of zooplankton, for example, if the restored area is on a creek that produces a net flow into the existing area.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Zooplankton Export from Suisun Marsh

One of the proposed restoration areas is in the northern end of Suisun Marsh. We estimated the subsidy of copepods to the LSZ from this region using IEP monitoring data and using a particle-tracking model to estimate exchange rate (Appendix E). If the copepods behaved as passive particles, this subsidy would amount to about 2%/d of the population in the LSZ. This is unlikely to produce a noticeable increase in copepod biomass, as their potential population growth rates are on the order of 10%/d. However, particles that migrate to the bottom tidally or remain near the bottom, as most zooplankton do in the estuary,[113] were essentially trapped within the northern marsh. Behavioral responses to tidal currents, consumption within the marsh, the distance from the mouth of the marsh to the habitat of the smelts, and the operations of the salinity control gate on Montezuma Slough would all reduce or even eliminate this subsidy.

The Real World

Several features of the actual restoration site would alter the subsidy to open waters from the analyses above. First, the enlarged restoration area will alter the tidal prism and therefore the exchange rate. The proposed restoration for Suisun Marsh would increase the inundated area 2-fold to 3-fold, with a corresponding increase in tidal currents. Since most of the exchange will be mediated by tides, this could substantially increase the exchange rate. Whether this would increase or decrease the subsidy would depend on the net population growth rate achieved in the marsh in relation to the exchange rate. Resolving the change in residence time would require a 3D model with very accurate bathymetry throughout the region. It is impossible to tell with available information whether the stronger tidal connections would result in a greater subsidy from Suisun Marsh, or whether this would be offset by zooplankton behavior or by consumption within the marsh. Such calculations could be done using a hydrodynamic and particle tracking model and some reasonable assumptions about zooplankton behavior.

The BDCP documents acknowledge (but then mostly ignore) that grazing by clams that settle in or near restored subtidal areas may remove all or most of the phytoplankton production and some of the zooplankton. Grazing by clams and zooplankton (including microzooplankton) removed all of the phytoplankton production in the LSZ nearly all the time from late

113. W. J. Kimmerer, *Effects of Freshwater Flow on Abundance of Estuarine Organisms: Physical Effects or Trophic Linkages?*, 243 MARINE ECOLOGY PROGRESS SERIES 39 (2002) [hereinafter Kimmerer 2002].

spring through fall during 1988-2008.[114] Whether clams settle in the newly restored areas is critical in determining whether the area can export any phytoplankton.[115] At present clams are not abundant in Suisun Marsh except for the larger Suisun and Montezuma Sloughs, where they probably remove a substantial fraction of the phytoplankton and small zooplankton that would otherwise enter Grizzly Bay.

Zooplankton organisms are not passive, and undergo tidal migrations in Suisun Bay.[116] It is very likely that they will do so also in marsh channels, which would greatly lengthen the residence time for copepods produced in the marsh, particularly in the far northern area of Suisun Marsh. In addition, several studies have shown that zooplankton organisms may also be consumed by various planktivorous fish within a marsh, resulting in a net flux of zooplankton into the marsh (see literature review above).

Finally, some of the proposed restoration sites are far from the centers of distribution of delta and longfin smelt. Travel times from these sites to where the fish are may be on the order of weeks to months in the dry season or when the North Delta diversions are operating.[117] A plankton population can double or halve its biomass in a few days depending on local food supply and predation. Thus, any export of zooplankton from a restored area should be assumed to subsidize only the local area.

All of these considerations are based on rather crude models of exchange and population processes. That is appropriate given the level of specificity of the BDCP design. Nevertheless, this analysis raises significant questions about the putative subsidy from restored areas to estuarine foodwebs. To address this uncertainty, long before any actual restoration takes place a program of analysis, modeling, and experimental restoration should be undertaken.

Likely Use of Restored Areas

Like other fish, smelt use a variety of habitats and appear to explore their environment to find suitable places for spawning, growth, and

114. Wim J. Kimmerer & Janet K. Thompson, *Phytoplankton Growth Balanced by Clam and Zooplankton Grazing and Net Transport into the Low-Salinity Zone of the San Francisco Estuary*, ESTUARIES AND COASTS (Jan. 2014), http://link.springer.com/article/10.1007/s12237-013-9753-6.

115. Lucas & Thompson 2012, *supra* note 79.

116. W. J. Kimmerer et al., *Tidally-Oriented Vertical Migration and Position Maintenance of Zooplankton in a Temperate Estuary*, 43 LIMNOLOGY & OCEANOGRAPHY 1697 (1998).; Kimmerer 2002, *supra* note 113.

117. Wim J. Kimmerer & Matthew N. Nobriga, *Investigating Particle Transport and Fate in the Sacramento-San Joaquin Delta Using a Particle Tracking Model*, SAN FRANCISCO ESTUARY & WATERSHED SCI. (Feb. 2008), http://escholarship.org/uc/item/547917gn.pdf.

development. As pelagic fish, their principal habitat is open waters of the estuary, either in freshwater during the larval to early juvenile stages in spring to early summer, or in the low-salinity zone until winter. The low-salinity zone during summer-fall is generally in the western Delta and Suisun Bay, including the channels of Suisun Marsh. Delta smelt appear to be surface oriented, which would allow them access to shallow areas.[118]

The fundamental problem for both smelt species in the open-water, brackish regions of the estuary is the low food supply (discussed above) and possibly also the decreasing turbidity.[119] Those trends may be difficult to reverse, spelling trouble ahead for the smelts. However, in recent years some proportion of the delta smelt population has remained in freshwater in the Cache Slough complex, despite high temperature there.[120] This may provide an alternative habitat in which the smelt population can either avoid poor conditions in the LSZ, or hedge its bets on future conditions. Longfin smelt are apparently not very abundant in Cache Slough.

Delta and longfin smelt have been collected in the Suisun Marsh fish survey.[121] Delta smelt are not common in Suisun Marsh during summer-fall but were formerly common in winter to early spring,[122] when the fish are migrating and spawning. About 0.7% of 3291 otter trawl samples from the Suisun Marsh survey during May-October of 1982-2009 and about 3% of 3320 samples during November-April contained delta smelt, mostly maturing juveniles and adults.[123] The low catches in summer were not due to small size of the fish, since young-of-the-year longfin smelt of the same size range were captured frequently in that program.[124] Temperature in the larger sloughs is ~1°C higher than in Grizzly Bay in July and August, based on IEP and UC Davis monitoring data, but if smelt avoid the warmer water in summer it does not explain the low catches for all of May-October. Longfin smelt are much more abundant in the Suisun Marsh channels than delta

118. Geir A. Aasen, *Juvenile Delta Smelt Use of Shallow-Water and Channel Habitats in California's Sacramento-San Joaquin Estuary*, 85 CAL. FISH & GAME 161 (1999), http://www.fws. gov/stockton/afrp/SWRCB/Aasen_1999.pdf.

119. W. J. Kimmerer, *Open Water Processes of the San Francisco Estuary: From Physical Forcing to Biological Responses*, SAN FRANCISCO ESTUARY & WATERSHED SCI. (Feb. 2004), http://escholarship.org/uc/item/9bp499mv.pdf.

120. Ted Sommer & Francine Mejia, *A Place to Call Home: A Synthesis of Delta Smelt Habitat in the Upper San Francisco Estuary*, SAN FRANCISCO ESTUARY & WATERSHED SCI. (June 2013), http://www.escholarship.org/uc/item/32c8t244.pdf [hereinafter Sommer & Mejia 2013].

121. Scott A. Matern et al., *Native and Alien Fishes in a California Estuarine Marsh: Twenty-One Years of Changing Assemblages*, 131 TRANSACTIONS AM. FISHERIES SOC'Y 797 (2002).

122. *Id.*

123. *Id.*

124. *Id.*

smelt, occurring in 8% of samples in May-October and 12% of samples in November-April with no obvious differences among the various sloughs.

The 20mm survey catches smelts during spring-summer in Montezuma Slough in Suisun Marsh and in central Suisun Bay including one station in Grizzly Bay near the major western entrance to the marsh. A graphical comparison of catch per trawl in these locations did not reveal a consistent difference for either species. A similar comparison of catch per trawl between Montezuma Slough and Grizzly Bay in the Fall Midwater Trawl survey also did not reveal a consistent difference, except that delta smelt were somewhat less abundant in the slough than in Grizzly Bay during September. Thus, it appears delta and longfin smelt are roughly as abundant in the larger sloughs of Suisun Marsh as in the open water of the estuary.

The key question for this aspect of restoration is whether additional physical habitat would result in larger populations of smelt. Abundance of delta smelt is related to an index of habitat availability based on salinity and turbidity.[125] However, the size of the LSZ (volume or area) does not seem to be strongly related to the abundance of either smelt species.[126] This may be because the LSZ is a contiguous stretch of water whose physical features are ephemeral, and the fish can move around readily within that region. In contrast, shallow tidal areas may offer enough physical structure to provide a wealth of sub-habitats with variable conditions. In that case, having more habitat area could lead to a greater abundance of fish. Note that a relationship between the quantity of habitat and the size of a fish population need not rely on a density-dependent relationship between habitat and the survival or reproduction of individual fish, which seems unlikely for delta smelt at current population levels.

Thus, we are cautiously optimistic that restoration of habitat may result in colonization and subsequent population expansion of delta smelt in the Cache Slough area including the Sacramento Ship Channel.[127] Longfin smelt seem unlikely to benefit from this. We cannot determine whether either species would benefit from similar restoration in the Suisun Marsh or the western Delta. The other restoration sites are too remote from the current population centers to offer much reason for optimism about their colonization by either smelt species.

125. Feyrer 2007, *supra* Chapter 6, note 11; Feyrer 2011, *supra* Chapter 6, note 12; Matthew L. Nobriga et al., *Long-Term Trends in Summertime Habitat Suitability for Delta Smelt*, Hypomesus Transpacificus, SAN FRANCISCO ESTUARY & WATERSHED SCI. (Feb. 2008), http://escholarship.org/uc/item/5xd3q8tx.pdf.

126. Kimmerer 2009, *supra* Chapter 6, note 11.

127. Peter B. Moyle, *The Future of Fish in Response to Large-Scale Change in the San Francisco Estuary, California*, *in* MITIGATING IMPACTS OF NATURAL HAZARDS ON FISHERY ECOSYSTEMS 357 (Katherine D. McLaughlin ed., 2008); Sommer & Mejia 2013, *supra* note 120.

D. Floodplain

The BDCP proposes to alter the Fremont Weir at the upstream end of the Yolo Bypass so that the Bypass would flood at lower stages of the Sacramento River. We consider here only the likely effects on the smelt species.

Review of Conceptual Basis

Although the smelt species do not use floodplain as habitat, elevated production of plankton on the floodplain may provide a subsidy to smelt habitat. This situation differs slightly from that of the potential subsidy from marshes discussed above. First, the floodplain is a flow-through system so that increased biomass of plankton will be transported by the mean, river-derived flow rather than by tidal flow. Second, residence time on a floodplain varies with flow conditions, from hours to a few days under high-flow conditions to effectively infinite in ponds remaining after the floodplain stops draining.

Analysis of Components

Apart from its suitability as habitat for fish and other species, the Yolo Bypass may also support foodwebs within the estuary. The mechanism for this would be higher phytoplankton and zooplankton production because of shallow depth and better light penetration than in river channels, as well as higher temperature.[128] Whether this translates to zooplankton is uncertain; zooplankton abundance on the Bypass was similar to that in the Sacramento River during 1998-2001.[129] Plankton biomass on a floodplain may increase late in the season as residence time increases and fish switch to larger prey,[130] but that was not observed on the Yolo Bypass in most years.[131]

At very high flows residence time on the Bypass is probably too short to allow for a buildup of biomass, while at lower flows such a buildup may occur but the rate of export may be low.[132] This implies that, as with tidal

128. Peggy W. Lehman et al., *The Influence of Floodplain Habitat on the Quantity and Quality of Riverine Phytoplankton Carbon Produced During the Flood Season in San Francisco Estuary*, 42 AQUATIC ECOLOGY 263 (2007).

129. Ted R. Sommer et al., *Effects of Flow Variation on Channel and Floodplain Biota and Habitats of the Sacramento River, California*, USA, 14 AQUATIC CONSERVATION: MARINE & FRESHWATER ECOSYSTEMS 247 (2004).

130. Edwin Grozholz & Erika Gallo, *The Influence of Flood Cycle and Fish Predation on Invertebrate Production on a Restored California Floodplain*, 568 HYDROBIOLOGIA 91 (2006).

131. Sommer, *supra* note 129.

132. Laurence Edward Schemel et al., *Hydrologic Variability, Water Chemistry, and Phytoplankton Biomass in a Large Floodplain of the Sacramento River*, CA, U.S.A., 513 HYDROBIOLOGIA 129 (2004).

exchange in marshes (Figure 7.3), there is an intermediate range of flow that maximizes export of plankton.

A subsidy from the Yolo Bypass may be more or less direct to delta smelt habitat, notably in the Cache Slough complex at the southern end of the Bypass. In addition, it may subsidize the low-salinity habitat used by both smelt species in late spring through fall.

In Appendix F we examine the evidence for a subsidy of zooplankton to the open water of the estuary under the current configuration using existing zooplankton data. We do not actually calculate the magnitude of the subsidy, since several factors would intervene to alter conditions. In particular, the Bypass could be flooded later in the year than is now the case, and the greater light penetration and higher temperature would provide for greater plankton production than now occurs. Furthermore, Bypass flow would represent a greater proportion of total inflow to the Delta later in the year, resulting in less dilution of the plankton coming off the Bypass.

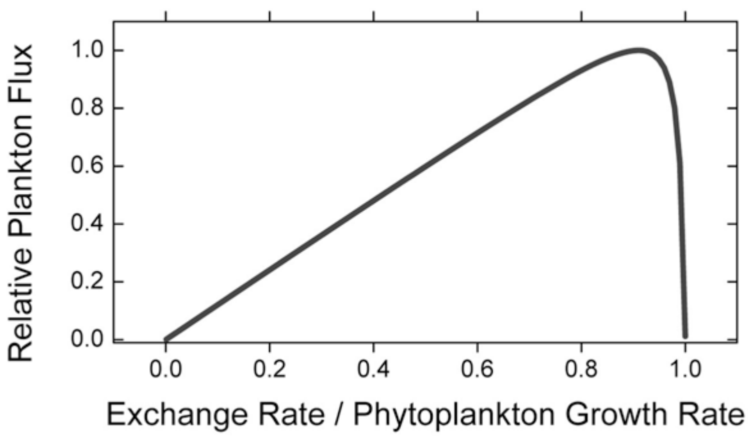


Figure 7.3. Relative magnitude of phytoplankton flux from a tidal marsh as a function of exchange rate, scaled to the growth rate of the phytoplankton. The model is based on a balance among import of nutrients to the marsh, uptake of nutrients to support growth of phytoplankton, and export of phytoplankton. All nutrient uptake is by phytoplankton, there is no consumption, and the phytoplankton concentration in the receiving water is zero.

[Note: Full-color figures available in complete copy of this article at http://journals.uchastings.edu/journals/websites/west-northwest/index.php.]

Our analysis shows no evidence that the open waters of the estuary receive a detectable subsidy of phytoplankton or zooplankton. If anything, plankton abundance is inversely related to Yolo Bypass flow, either during the month of sampling between flow during the winter and zooplankton abundance in the following summer.

E. Conclusions

There are many reasons for restoring physical habitat in the Delta and Suisun Marsh, and a host of species that are likely to benefit. Among the listed fish species, young salmon use marsh and floodplain during residence, salutatory downstream movement, and active migration. However, it is unclear whether conditions in the Delta have a substantial role in the population dynamics of salmon, and therefore we have elected to focus on the smelt species, for which the Delta is a key part of home.[133]

The BDCP is overly optimistic about the potential benefits to delta and longfin smelt of physical habitat restoration. Longfin smelt do not appear to use marshes as habitat to any great extent. Delta smelt are also considered pelagic but their persistent abundance in the Cache Slough complex, and greater abundance in shallow rather than deep water, suggests some potential benefit to their population of expanded marsh in that area. The magnitude of this benefit is impossible to predict, as is the degree to which marsh and floodplain restoration might cause an increase, or reverse the decline, in the delta smelt population. Under these conditions it is premature to assert that the restoration activity will have such an effect, until studies including pilot projects and even some smaller full-scale restoration projects can show whether an effect is to be expected.

The idea that restored marsh and floodplain will export substantial amounts of zooplankton to the open waters of the estuary is not tenable. The ecology of shallow waters suggests that shallow areas are more likely to be sinks for zooplankton. Even if they were sources, simple mass-balance considerations indicate that the resulting export would produce at most a small enhancement of extant zooplankton of the open waters. This idea should be dropped from discussions of BDCP, although experimental work should press ahead to determine under what conditions marsh habitats could be sources of significant food for delta and longfin smelt in the open waters.

Chapter 8: Regulatory Oversight and Assurances

A. Introduction

The previous chapters have demonstrated the relatively high uncertainties associated with proposed conservation actions in BDCP. These uncertainties will likely result in the need to change Plan goals and

133. Sommer & Mejia 2013, *supra* note 120.

objectives in the future, along with the prescribed conservation measures to address them.

This chapter addresses the question whether the draft BDCP includes governance policies that are "transparent and resilient to political and special interest influence." We divide our analysis into two parts: (1) analysis of the regulatory oversight of plan implementation and adaptive management; and (2) evaluation of the regulatory assurances and proposed 50-year "no surprises" guarantee.

B. Regulatory Oversight

Introduction

The draft BDCP vests primary responsibility for implementing the Plan in a Program Manager, who shall "ensure that the BDCP is properly implemented throughout the duration of the Plan."[134] The Program Manager's authority is broad and includes protection and restoration of habitat, reduction of ecological stressors, management of conserved habitat, coordinated operation of the CVP and SWP, and development of the new facilities authorized by the Plan.[135]

The Program Manager's implementation of the BDCP is subject to oversight by the Authorized Entity Group, which will be comprised of the Director of the California Department of Water Resources as operator of the SWP, the Regional Director of the U.S. Bureau of Reclamation as operator of the CVP, and one representative each of the CVP and SWP contractors if the contractors are issued permits under the Plan.[136] The BDCP also covers certain diversions of water that are not part of CVP or SWP operations and recognizes that these water supply operators may seek incidental take permits under the terms and conditions of the BDCP. If this occurs, these water projects would become Authorized Entities, but would not be members of the Authorized Entity Group.[137]

134. DRAFT BDCP, at 7-2.

135. *Id.* at 7-3. The Program Manager also will have responsibility over the Implementation Office, which will assist the Program Manager in all aspects of implementation of the Plan, and the Science Manager and Adaptive Management Team. *Id.* at 7-3 to 7-8. The Science Manager and Adaptive Management Team are discussed in greater detail in Chapter 9, *infra*, of this report.

136. *Id.* at 7-8. A question has arisen whether the fish and wildlife agencies legally may grant incidental take permits to the CVP and SWP contractors under the federal Endangered Species Act and the California Natural Community Conservation Planning Act. We address this question in the Appendix G, *infra*.

137. DRAFT BDCP, at 7-8.

The Authorized Entity Group's authority over the BDCP also is broad and multifaceted. The draft BDCP states:

> The Authorized Entity Group will provide oversight and direction to the Program Manager on matters concerning the implementation of the BDCP, provide input and guidance on general policy and program-related matters, monitor and assess the effectiveness of the Implementation Office in implementing the Plan, and foster and maintain collaborative and constructive relationships with the State and federal fish and wildlife agencies, other public agencies, stakeholders and other interested parties, and local government throughout the implementation of the BDCP.[138]

This oversight structure means that the Authorized Entity Group will exercise significant authority over both the coordinated operation of the CVP and SWP and implementation of the BDCP itself. Indeed, the draft Plan declares that the Program Manager "will report to the Authorized Entity Group, and act in accordance with the group's direction."[139]

The draft Plan vests regulatory responsibility within the BDCP in a "Permit Oversight Group," which is composed of the Regional Director of the U.S. Fish and Wildlife Service, the Regional Administrator of the National Marine Fisheries Service, and the Director of the California Department of Fish and Wildlife.[140] It then states that the three agencies "are expected to issue regulatory authorizations to the Authorized Entities" pursuant to the federal Endangered Species Act and the California Natural Community Conservation Act.[141]

The draft Plan also provides that, "[c]onsistent with their authorities under these laws, the fish and wildlife agencies will retain responsibility for monitoring compliance with the BDCP, approving certain implementation actions, and enforcing the provisions of their respective regulatory authorizations."[142] This means that, although the USFWS, NMFS, and CDFW will work together as members of the Permit Oversight Group for the purpose of supervising implementation of the BDCP, each agency will retain its independent regulatory powers over the CVP, SWP, and other water users under the federal and state Endangered Species Acts.[143]

---

138. *Id.* at 7-8 to 7-9.

139. *Id.* at 7-2.

140. *Id.* at 7-11.

141. *Id.*

142. *Id.*

143. As described below, *infra* p. 346, this independent regulatory authority is subject, however, to an important caveat—the draft Plan's requirement of

This structure is consonant with both the Endangered Species Acts and the California Natural Community Conservation Planning Act, because it separates the regulatory oversight responsibilities of the federal and state fish and wildlife agencies from the operational responsibilities of the Program Manager and the Authorized Entity Group. This structural delineation is undermined, however, by the draft Plan's more detailed definition of the "function" of the Permit Oversight Group, which blurs the distinction between implementation and regulation. It also is undermined by provisions in the draft Plan that grant the Authorized Entity Group—rather than the regulatory agencies—veto authority over changes to the conservation measures, biological objectives, and adaptive management strategies, as well as over amendments to the BDCP itself.

Regulatory Versus Programmatic Responsibilities: Implementation

The draft Plan grants the Permit Oversight Group a significant role in implementing the conservation goals and adaptive management strategies of the BDCP:

> The Permit Oversight Group will be involved in certain decisions relating to the implementation of water operations and other conservation measures, actions proposed through the adaptive management program or in response to changed circumstances, approaches to monitoring and scientific research.[144]

It then provides that the Permit Oversight Group "will have the following roles, among others, in implementation matters":

- *Approve, jointly with the Authorized Entity Group*, changes to conservation measures or biological objectives proposed by the Adaptive Management Team.
- *Decide, jointly with the Authorized Entity Group*, all other adaptive management matters for which concurrence has not been reached by the Adaptive Management Team.
- Provide input into the selection of the Program Manager and the Science Manager.
- *Provide input and concur* with the consistency of specified sections of the Annual Work Plan and Budget with the BDCP and with certain agency decisions.
- *Provide input and concur* with the consistency of the Annual Delta Water Operations Plan with the BDCP.

consistency between future section 7 consultations and the BDCP. DRAFT BDCP, at. 7-8 to 7-9.

144. DRAFT BDCP, at 7-11.

- Provide input and accept Annual Reports.
- P*rovide input and approve* plan amendments.[145]

These definitions are poorly drafted, and they assign programmatic authority to the fish and wildlife agencies that may undermine their regulatory responsibilities. We therefore recommend that the draft BDCP be revised in two ways:

First, where the parties to the negotiations want to grant the Permit Oversight Group authority to determine whether certain actions or documents are consistent with the BDCP, the Plan should define its responsibilities more clearly and precisely than does the current language—e.g., "provide input and concur"; "provide input and accept"; and "provide input and approve." Thus, the draft Plan should be revised to state:

> The Permit Oversight Group shall have exclusive authority to determine whether the Annual Work Plan Budget and Annual Delta Operations Plan are consistent with the BDCP. If the Permit Oversight Group does not issue a determination of consistency, the document in question shall be revised and resubmitted to the Permit Oversight Group for approval or further remission and revision.

Second, the Permit Oversight Group's role should be limited to regulatory oversight. The "functions" listed in the draft Plan conflate the Permit Oversight Group's regulatory responsibilities with the programmatic implementation duties that are best left with the Program Manager and the Authorized Entities Group. Although there is some practical value in collaboration among the regulators and the regulated—e.g., having the fish and wildlife agencies give their "input" during the drafting of annual operations plans—it is better policy to maintain the exclusive regulatory role of the Permit Oversight Group. A regulatory agency that has a stake in the creation of the program and policy decisions that it must ultimately review will not be able to bring its independent judgment to bear in

145. *Id.* at 7-11 to 7-12 (emphasis added). The draft Plan also contains a placeholder "function," which states that the Permit Oversight Group also may play a role in "decision-making regarding real-time operations, consistent with the criteria of CM1 *Water Facilities and Operation* and other limitations set out in the BDCP and annual Delta water operations plans." *Id.* at 7-11. As the details of this role as still under negotiation, we do not address it here except to note that the role of the Permit Oversight Group should be clearly defined and limited to regulatory oversight as explained in the text.

evaluating those same decisions for consistency with the Plan and other applicable laws.

The conflation of regulatory and programmatic responsibilities is especially dangerous in the case of revisions to the biological objectives, conservation measures, and other adaptive management strategies. As currently written, the draft Plan grants the Authorized Entity Group an effective veto over proposed changes to the these programs, even if the Adaptive Management Team, the Science Manager, the Program Manager, and the Permit Oversight Group have concluded that changes are needed to ensure programmatic compliance with the BDCP or to fulfill the requirements of the federal and state Endangered Species Acts.[146]

A better course would be to revise the draft Plan to allow the Science Manager and Adaptive Management Team—subject to oversight and approval from the Program Manager and Authorized Entity Group—to make revisions to the biological objectives, conservation measures, and other adaptive management strategies. These changes then would be submitted to the Permit Oversight Group for review and approval or remission. The Permit Oversight Group also should have independent authority to revise the biological objectives, conservation measures, and other adaptive management strategies if it concludes that the existing programs are inadequate to comply with the BDCP or other governing law.

Regulatory Versus Programmatic Responsibilities: Policy Modifications and Amendments to the BDCP

A similar problem exists for modifications to the BDCP itself. The draft Plan recognizes that "Plan modifications may be needed periodically to clarify provisions or correct unanticipated inconsistencies in the documents."[147] It then identifies three types of plan modifications: administrative changes, minor modifications, and formal amendments. Only the latter two concern us here.

The draft Plan defines "minor modifications" as including transfers of acreage between Restoration Opportunity Areas or conservation zones and "[a]djustments of conservation measures or biological objectives . . . consistent with the monitoring and adaptive management program and intended to enhance benefits to covered species."[148] It then describes "formal amendments" as including, but not limited to:

- Changes to the geographic boundary of the BDCP.
- Additions of species to the covered species list.

146. *Id.* at 7-11.

147. *Id.* at 6-45.

148. *Id.* at 6-46.

- Increases in the allowable take limits of covered activities or the addition of new covered activities to the Plan.
- Substantial changes in implementation schedules that will have significant adverse effects on the covered species.
- Changes in water operations beyond those described under CM1 *Water Facilities and Operations*.[149]

The "minor modifications" and "formal amendments" thus include all aspects of BDCP implementation that will be vital to the success or failure of the BDCP. Yet, the draft Plan expressly provides that the Authorized Entities may veto any such changes.[150] For minor modifications, the draft BDCP states: "If any Authorized Entity disagrees with the proposed minor modification or revision for any reason, the minor modification or revision will not be incorporated into the BDCP."[151] The draft Plan similarly declares that formal amendments "will be subject to review and approval by the Implementation Office and the Authorized Entities."[152]

The BDCP is fundamentally a set of terms and conditions that allow the principal regulatory agencies—the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the California Department of Fish and Wildlife—to authorize the construction and operation of physical improvements to the Delta that will facilitate more reliable (and, one may hope, more environmentally sustainable) exports of water by the CVP and SWP. Although the motivating purpose of the BDCP is to facilitate this water development, the regulatory agencies' foundational responsibility is

149. *Id.* at 6-47.

150. *Id.* at 6-46 to 6-47. Please note that the draft BDCP states that the Authorized Entities—not the Authorized Entity Group—hold this veto power. *Id.* This may be a typographical error, as the Authorized Entities are not granted implementation decision-making authority (except through the Authorized Entity Group) any other place in the document. If it the BDCP negotiators in fact intend to vest veto authority in the Authorized Entities, however, this is especially problematic as the Authorized Entities potentially include water users other than those that comprise the Authorized Entity Group. *Id.* at 7-8.

151. *Id.* at 6-46. By contrast, if any of the fish and wildlife regulatory agencies disagrees with a proposed minor modification, its rights are limited to insisting that the proposal be treated as a formal amendment to the Plan. *Id.*

152. *Id.* at 6-50. At least in the case of formal amendments the draft Plan recognizes a relative parity in the rights of the regulators and the regulated, acknowledging that such amendments "will require corresponding amendment to the authorizations/ permits, in accordance with applicable laws and regulations regarding permit amendments." *Id.* It also states, however, that the "fish and wildlife agencies will use reasonable efforts to process proposed amendments within 180 days." *Id.* at 6-46.

to ensure that the project does not jeopardize the continued existence of the species that are listed for protection under the federal and state Endangered Species Acts.

To accomplish this essential obligation, the fish and wildlife agencies must both insist on an initial set of biological objectives, conservation measures, and conditions on coordinated project operations that will fulfill this purpose; *and* they must have the means of ensuring that the implementation of the BDCP will continue to achieve that goal throughout its 50-year term.

We do not believe that the draft Plan satisfies this second requirement, as it vests veto authority over necessary changes in the biological objectives, conservation measures, adaptive management strategies, and the terms and conditions of the BDCP itself, not in the regulatory agencies, but in the regulated entities that comprise the Authorized Entity Group. We therefore recommend revision of the draft Plan to require that all "minor modifications" and "formal amendments" to the BDCP be subject to review and approval by the Permit Oversight Group.

As explained above, we also recommend that the draft Plan be revised to authorize the Permit Oversight Group itself to initiate and make changes to the biological objectives, conservation measures, and other adaptive management strategies that the fish and wildlife agencies conclude are needed to ensure the protection and recovery of the species listed under the federal and state Endangered Species Acts. This unilateral authority must extend to all of the identified "minor modifications" and to at least one of the defined "formal amendments"—viz. "substantial changes in implementation schedules that will have significant adverse effects on the covered species."[153]

The other listed "formal amendments"—which include alteration of the geographic boundaries of the Plan and the addition of new species and covered activities—are different, as they include possible changes to the

153. *Id.* at 6-47. The governance structure set forth in the current draft Plan also may jeopardize the likelihood that the BDCP will be incorporated into the Delta Plan. *See* CAL. WATER CODE §§ 85320-85322 (2013). The Delta Reform Act of 2009 provides:

> The BDCP shall include a transparent, real-time operational decision-making process in which *fishery agencies ensure that applicable biological performance measures are achieved in a timely manner with respect to water system operations*.

CAL. WATER CODE § 85321 (emphasis added). The Authorized Entity Group's veto authority over changes to the biological objectives, conservation measures, and adaptive management strategies means that the fish and wildlife agencies would not have the power to ensure that the biological measures will be achieved. The draft Plan therefore violates this statutory mandate, and the CDFW and the Delta Stewardship Council consequently would likely be precluded from incorporating the BDCP into the Delta Plan.

scope and structure of the BDCP, rather than adaptive changes to the implementation and achievement of the goals of the existing BDCP. These formal amendments therefore are properly subject to approval of both the Permit Oversight Group and the Authorized Entity Group.[154]

C. Regulatory Assurances and the "No Surprises" Policy

Introduction

The draft Plan proposes to create two types of "regulatory assurances." First, it seeks to eliminate the uncertainties associated with consultation under section 7 of the federal Endangered Species Act for coordinated CVP and SWP operations by stipulating that future biological opinions shall be consistent with the terms and conditions of the BDCP. Second, it offers "no surprises" guarantees both for deviations between the biological opinions and the BDCP and for future changes to the BDCP itself. In addition, the draft Plan places difficult scientific, legal, and political burdens on the state and federal governments' power to terminate the incidental take permits and to rescind the BDCP.

In our judgment, these regulatory assurances compound the risks described in the preceding section because they severely constrain the fish and wildlife agencies' ability to respond to inadequacies in the biological objectives, conservation measures, and other adaptive management strategies—even apart from the veto authority that the draft Plan vests in the Authorized Entity Group.

Section 7 Consultation and the BDCP

According to the draft Plan, once the facilities authorized by the BDCP are constructed, the Plan will largely displace the existing section 7 consultation requirements[155] applicable to coordinated CVP and SWP operations: "On the basis of the BDCP and the companion biological assessment, it is expected that USFWS and NMFS will issue a new joint biological opinion (BiOp) that would supersede BiOps existing at that time as they relate to SWP and CVP actions addressed by the BDCP."[156] The draft Plan then requires that the new biological opinion (as well as any

154. It is worth noting that even this limited "bilateral" approval process for structural amendments to the BDCP may not be consistent with federal law. The ESA rules provide that all incidental take permits "are issued subject to the condition that the National Marine Fisheries Service reserves the right to amend the provisions of a permit for just cause at any time during its term." 50 C.F.R. § 222.306(c).

155. 16 U.S.C. § 1536 (2013).

156. DRAFT BDCP, at 4-2.

subsequent biological opinions issued during the 50-year term of the BDCP) be consistent with the terms and conditions of the BDCP itself:

> The BDCP is intended to meet the requirements of the ESA and provide the basis for regulatory coverage for a range of activities identified in the Plan. . . .
>
> Unless otherwise required by law or regulation, in any Section 7 consultation related to a covered activity or associated federal action and covered species, USFWS and NMFS will ensure that the resulting BiOps are consistent with the integrated BiOp for the BDCP.[157]

We do not necessarily object to this consistency directive. An important goal of the BDCP is to provide all parties—especially the Authorized Entities—with a measure of regulatory and operational certainty that will enable them both to invest in the new facilities and to make water management decisions in their respective service areas in reliance on water deliveries from the CVP and SWP. To the extent that future section 7 consultations conform to the terms of the BDCP, that certainty is enhanced. We also note the first clause of the second sentence quoted above, which expressly reserves the authority of USFWS and NMFS to issue biological opinions that depart from the terms of the BDCP if necessary to comply with the governing law. This law, of course, includes section 7(a)(2) of the federal ESA, which requires all consulting agencies to ensure that their actions are "not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical] habitat."[158]

We do believe, however, that the proposal to substitute the BDCP for section 7 consultation as the principal means of applying the federal ESA to the CVP, SWP, and other Authorized Entities reinforces our recommendations from the preceding section—viz. that the Permit Oversight Group must maintain the independent regulatory prerogatives that the fish and wildlife agencies currently possess and must have authority to approve or to deny proposed changes in the biological objectives, conservation measures, and other terms and conditions of the BDCP as required to protect and recover the species covered by the Plan. Our support for the biological opinion/BDCP consistency directive should be read with this caveat.

157. *Id.*, at 6-47.

158. 16 U.S.C. § 1536(a)(2).

"No Surprises"

The draft Plan contains two "no surprises" guarantees. The first applies to changes in coordinated CVP and SWP operations or water supply capabilities that may be required by future biological opinions that do not conform to the BDCP. The second is a more general "no surprises" commitment that protects the Authorized Entities from certain changes to the BDCP itself.

According to the draft Plan, "Ecological conditions in the Delta are likely to change as a result of future events and circumstances that may occur during the course of the implementation of the BDCP."[159] The draft then lists seven "Changed Circumstances Related to the BDCP"—levee failures, flooding, new species listings, wildfire, toxic or hazardous spills, nonnative invasive species, and climate change.[160] For each of these "reasonably foreseeable" changes, the draft Plan describes the "planned responses" that BDCP administrators will undertake.[161] The draft Plan states that the responses "have been designed to be practical and roughly proportional to the impacts of covered activities on covered species and natural communities, yet sufficient to effectively address such events."[162] The BDCP budget will include funds to cover the costs of implementing some of the planned responses to "reasonably foreseeable" changed circumstances.[163]

159. DRAFT BDCP, at 6-30.

160. *Id.* at 6-31.

161. *Id.* at 6-31 to 6-42. The Implementation Office is charged with identifying the onset of a changed circumstance, working with the Permit Oversight Group to fashion a response, and for implementing and monitoring the responsive actions. *Id.* at 6-31.

162. *Id.* at 6-30.

163. *Id.* This funding process is described in Chapter 8 of the draft BDCP. *Id.* at 8-60 to 8-64. The draft states generally that, to "allow for the ability to respond to changed circumstances should they occur, the Implementation Office should maintain a reserve fund for covering costs of changed circumstances" *Id.* at 8-61. The draft Plan explains that this is because "the risk of some changed circumstances—*e.g.*, failure of levees attached to tidal marsh and floodplain restoration—and cost of remedial measures increases as greater portions of the conservation strategy are implemented." *Id.*

The draft BDCP only includes levee failure and wildfire damage to preserved lands as possible "changed circumstances for which responses are expected to result in additional implementation costs." *Id.* It omits "changed circumstances related to climate change, flooding, failure of water operations infrastructure, nonnative invasive species, new species listings, and toxic or hazardous spills," explaining that the response costs for these are accounted for in the initial BDCP funding, will be paid by the state and federal governments under the "no surprises" guarantees, or would be the responsibility of a third party. *Id.* at 8-61 to 8-62.

The draft Plan also recognizes that "unforeseen circumstances" may require changes to the biological objectives, conservation measures, adaptive management strategies, or the terms and conditions of the BDCP itself. It defines unforeseen circumstances as "changes in circumstances that affect a species or geographic area covered by an HCP that could not reasonably have been anticipated by the plan participants during the development of the conservation plan, and that result in a substantial and adverse change in the status of a covered species."[164] The draft Plan contains a similar definition of "unforeseen circumstances" under state law. These are "changes affecting one or more species, habitat, natural community, or the geographic area covered by a conservation plan that could not reasonably have been anticipated at the time of plan development, and that result in a substantial adverse change in the status of one or more covered species."[165]

The draft Plan then sets forth the following regulatory assurances under federal and state law:

> Under ESA regulations, if unforeseen circumstances arise during the life of the BDCP, USFWS and/or NMFS may not require the commitment of additional land or financial compensation, or additional restrictions on the use of land, water, or other natural resources other than those agreed to in the plan, unless the Authorized Entities consent.[166]
>
> In the event of unforeseen circumstances, CDFW will not require additional land, water, or financial compensation or additional restrictions on the use of land, water, or other natural resources without the consent of the plan participants for a period of time specified in the Implementation Agreement.[167]

As noted above, for federal agencies that are subject to section 7 consultation (including consultation for coordinated CVP/SWP operations), the draft Plan contains an additional "no surprises" pledge if new biological opinions contain operational or water supply restrictions that differ from those set forth in the BDCP:

164. *Id.* at 6-42 (citing 50 C.F.R. § § 17.3, 222.102 (2013)).

165. *Id.* at 6-43 (citing CAL. FISH & GAME CODE § 2805(k) (2013)).

166. *Id.* at 6-42.

167. *Id.* at 6-43. The draft Plan notes that, under California law, "such assurances are not applicable in those circumstances in which CDFW determines that the plan is not being implemented in a manner consistent with the substantive terms of the Implementation Agreement." *Id.* at 6-43 (citing CAL. FISH & GAME CODE § 2820(f)(2)).

> Furthermore, USFWS and NMFS will not require additional land, water, or other natural resources, or financial compensation or additional restrictions on the use of land, water, or other natural resources regarding the implementation of covered activities beyond the measures provided for under the BDCP, the Implementing Agreement, the incidental take permits, and the integrated BiOp.[168]

The purpose of these regulatory assurances is to exempt the Authorized Entities from any of the costs of complying with the federal and state Endangered Species Acts except as defined in (and funded pursuant to) the terms of the BDCP. These "no surprises" guarantees therefore may place the financial burden of some future changes to the BDCP and project operations exclusively on state and federal taxpayers.

Although both federal Endangered Species Act regulations and the California Natural Community Conservation Planning Act authorize "no surprises" guarantees, we believe, given the uncertainties outlined in the previous chapters, that there is a significant risk that the costs of compensating the projects and their contractors for future "unforeseen" hydrologic, engineering, and operational changes will be excessive. More importantly, we are concerned that the state and federal governments' assumption of liability may deter the fish and wildlife agencies from making changes to future biological opinions or to the BDCP itself that the agencies believe are necessary to protect and recover listed species. The following example focusing on the "reasonably foreseeable" changed circumstance of climate change illustrates our concerns.

The draft Plan defines climate change as "[l]ong-term changes in sea level, watershed hydrology, precipitation, temperature (air or water), or ocean conditions that are of the magnitude or effect assumed for the effects analysis and that adversely affect conservation strategy implementation or covered species are considered a changed circumstance."[169] It then provides that the "occurrence of this changed circumstance will be determined jointly by the Implementation Office and fish and wildlife agencies."[170]

According to the draft Plan, however, alterations in the ecosystem and threats to listed species caused by climate change will not trigger any management or regulatory responses beyond those set forth in the BDCP. "Because the BDCP already anticipates the effects of climate change, no

168. *Id.* at 6-44.

169. *Id.* at 6-41.

170. *Id.* We reiterate here the problems that we identified in the preceding section: conflation of the fish and wildlife agencies' regulatory and programmatic roles and the granting of an effective veto to the regulated entities through the Implementation Office.

additional actions will be required to remediate climate change effects on covered species and natural communities in the reserve system."[171] Rather, the Adaptive Management Team will monitor these changes and the Implementation Office will "continually adjust conservation measures to the changing conditions in the Plan Area as part of the adaptive management program."[172]

The draft Plan also states that all responses to climate change

> will be made as part of the adaptive management and monitoring program. Measures beyond those contemplated by the adaptive management and monitoring program are not likely to be necessary because the conservation strategy was designed to anticipate a reasonable worst-case scenario of climate change. A *change in conservation measures in response to climate change beyond that considered in* Chapter 3, Conservation Strategy, *and through the adaptive management and monitoring program is considered an unforeseen circumstance*."[173]

There are two serious problems with this changed circumstances strategy:

First, although the "biological goals and objectives [of the BDCP] have been established at the landscape level to take climate change into account during conservation strategy implementation,"[174] and the "conservation strategy, monitoring and research program, and adaptive management and monitoring program already include responses to anticipate climate change effects at the landscape, natural community, and species scales,"[175] the draft Plan correctly anticipates that the biological objectives, conservation measures, and other adaptive management strategies are likely to be modified over time as required to respond to the changed conditions brought about by climate change. Yet, as described previously, all such modifications are subject to approval by the Authorized Entities.[176] The fish and wildlife agencies consequently lack independent authority to determine the appropriate policy and management responses to climate change, even within the confines of the defined responses set forth in Chapter 3 of the BDCP.

Second, changes in conservation measures that differ from the defined responses are "unforeseen circumstances," which trigger the "no surprises"

171. *Id.*

172. *Id.* at 6-42.

173. *Id.* at 6-44 to 6-45 (emphasis added).

174. *Id.* at 6-46.

175. *Id.* at 6-44.

176. *Id.* at 6-46 to 6-47.

guarantee. Again, while the draft Plan anticipates a broad array of ecological changes likely to be caused by climate change, and lays out a detailed set of programmatic responses, it is folly to believe that the BDCP scientists and negotiators have correctly identified all of the hydrologic changes, biotic responses, and risks to the ecosystem that will in fact occur over time. As one recent interdisciplinary study of California water policy emphasized:

> New approaches to ecosystem management under changing conditions will require continued, large-scale experimentation aided by computer modeling. This task is complex, because experiments, especially on a large scale, often yield ambiguous results. Also, as with hydrology, the past is not always a good predictor of the future with many ecosystems. Linking human and natural systems, combined with changes in climate and influxes of alien species, creates novel, dynamic ecosystems with no historical analog. Thus, efforts to restore ecosystem functions and attributes involve hitting a moving, only partially visible target. Finally, ecosystem changes are often nonlinear and interrelated. Declines in habitat quality or abundance reduce ecosystem resiliency, with the result that even small changes in conditions can lead to abrupt system collapse and reorganization to a new state. Such thresholds or tipping points are difficult to predict. *Taken together, these factors suggest that efforts to improve conditions for California's native aquatic species will necessarily involve trial and error, and that success is far from guaranteed.*
>
> . . . .
>
> The difficulty is compounded by the high uncertainty of success for specific actions, given ecosystem complexity, gaps in knowledge of how to manipulate many key processes, and, most important, continuing change in climate, invasive species, and other conditions in California. . . . . *As a result, a flow regime or water quality target that seems adequate today may not provide the same services in 20 to 30 years. Aiming at a moving target in semi-darkness means that there will be many misses.*[177]

The potential consequences of the "no surprises" guarantee in this context are troubling. Fisheries biologists generally agree that diminished seasonal outflow and warming water temperatures place several listed species at risk of extinction.[178] The projects that would be authorized by the

177. ELLEN HANAK ET AL., MANAGING CALIFORNIA'S WATER: FROM CONFLICT TO RECONCILIATION 174, 248 (2011) (emphasis added).

178. *E.g.* James E. Cloern et al., *Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change*, PLOS ONE, Sept. 21, 2011, at 1, 9-11;

BDCP should reduce some of the sources of stress on these species by reducing entrainment and predation and by creating substitute habitat, but they will not address several other important stressors such as diminished summer and fall outflow and rising water temperatures. Therefore, sometime during the 50-year term of the BDCP, it may be necessary to construct additional upriver storage (e.g., by increasing the capacity of Shasta Reservoir) to enable more sustained cold-water releases to protect salmon spawning and out-migration.

Yet, under the draft Plan, this action would constitute an "unforeseen circumstance," because it falls outside the defined responses to climate change set forth in the BDCP. The consequence would be that the state and federal taxpayers would have to bear all of the costs of constructing and operating the new or expanded storage, even though the fish and wildlife agencies determined that this action is needed to protect one or more listed species from extinction (while maintaining reservoir releases and exports at the levels and timing authorized by the BDCP).

Alternatively, if funding were not available to construct the new storage capacity, and the fish and wildlife agencies made jeopardy findings and issued new biological opinions that altered reservoir release requirements in a manner that reduced water supply or export capacity, the state and federal governments would have to compensate the Authorized Entities for the value of the lost water or the cost of replacement supplies.[179]

Peter B. Moyle et al., *Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach*, PLoS ONE, May 22, 2013, at 1, 10-11.

179. The Director of the California Department of Water Resources, Mark Cowin, has stated that it was not the parties' intent to apply the "no surprises" policy to actions taken outside the plan area that may be required to address the effects of climate warming or other changed conditions on listed species. Meeting with Mark Cowin, Director, Cal. Dep't Water Res., and Chuck Bonham, Director, Cal. Dep't Fish & Wildlife (July 23, 2013). Although we were pleased to learn this, we retain the concerns described in the text for two reasons: First, the draft Plan does not state that new infrastructure or operational changes needed to ensure the survival of species covered by the BDCP are exempt from the "no surprises" guarantee if they are located outside the plan area. Rather, the draft links CVP and SWP facilities and water supply operations upstream of the plan area to the conservation measures that may be required to protect covered species and their downstream habitat. DRAFT BDCP, at 1-20. Without an explicit limitation on the "no surprises" guarantee to new, "unforeseen" conservation measures undertaken within the plan area, we believe that there is an unacceptable risk that the Authorized Entities could raise a plausible claim that the "no surprises" policy exempts them from liability for new facilities and operational changes upstream of the plan area that are needed to protect covered species within the plan area.

Second, the draft Plan expressly extends the "no surprises" assurance for future section 7 consultations over new facilities and other changes in CVP operations that

For these reasons, we do not believe that the 50-year "no surprises" guarantees are wise or prudent policy. We understand that the Authorized Entities seek to protect their capital investment and obtain maximum security of their water service capabilities, and that a relatively fixed set of biological objectives, conservation measures, and operational constraints help to achieve these goals.[180] But a 50-year commitment is illadvised in an ecosystem as complex, variable, and scientifically inscrutable as the Delta. As our colleague Peter Moyle has observed, in the Delta Ecosystem, "[o]ver-negotiation of details in advance is unlikely to enable adequate responsiveness and flexibility" and "even the most well-informed, scientifically based management will encounter surprises and make mistakes."[181]

The parties to the BDCP negotiations therefore should consider separate "no surprises" guarantees—one governing construction of the BDCP projects, and a series of operational "no surprises" commitments that would be reevaluated every ten years based on *current* information on the appropriateness of the biological objectives, the success or failure of the conservation measures, species survival and recovery, overall ecosystem health, climate change, invasive species, discharges, the effects of authorized project operations, other stressors, and regulatory compliance.

We have chosen ten years for the recommended length of renewable "no surprises" assurances because a 10-year period is likely to include a variety of different types of water years and thus will be sufficiently lengthy to enable BDCP managers and regulators to evaluate how well the biological objectives and conservation measures perform across a spectrum of hydrologic conditions. At the same time, ten years is short enough to minimize the risk that the terms and conditions of the BDCP become antiquated and ineffective in light of the inevitable and unpredictable changes to the ecosystem. Indeed, a series of renewable 10-year "no

are outside the plan area and not part of the BDCP covered activities. The draft Plan stipulates that "USFWS and NMFS will further ensure that the terms of any BiOp issued in connection with projects that are independent of the covered activities and associated federal actions do not create or result in any additional obligation, cost, or expense to the Authorized Entities." *Id.* at 6-44.

If the parties to the BDCP negotiations do not intend for the "no surprises" guarantee to cover new construction and project operational changes outside the plan area, then they should revise the draft Plan to say so explicitly and clearly. We also recommend that the sentence quoted above, which exempts the Authorized Entities from all costs associated with section 7 consultations to project facilities and operations other than BDCP covered activities be deleted.

180. DRAFT BDCP, at 1-26.

181. PETER B. MOYLE, WILLIAM BENNET, JOHN DURAND, WILLIAM FLEENOR, BRIAN GRAY, ELLEN HANAK, JAY LUND & JEFFREY MOUNT, WHERE THE WILD THINGS AREN'T: MAKING THE DELTA A BETTER PLACE FOR NATIVE SPECIES 5 (2012).

surprises" guarantees could create a constructive incentive for the parties to the BDCP to monitor progress and achievement of the biological objectives and conservation measures and to make adaptive management changes as required to sustain and recover the covered species and their habitat.[182]

Revocation of Incidental Take Permits and the BDCP

Many of our concerns about the rigidities of the draft Plan and the scope and length of the regulatory assurances would be lessened if there were an effective means of revoking the incidental take permits and thus rescinding the BDCP. But there is not.

As described in the draft Plan, the "Permit Revocation Rule," adopted in 2004, allows the federal fish and wildlife agencies

> to nullify regulatory assurances granted under the No Surprises rule and revoke the Section 10 permit only in specified instances, including where continuation of a permitted activity would jeopardize the continued existence of a species covered by an HCP and the impact of the permitted activity on the species has not been remedied in a timely manner.[183]

---

182. There is nothing in federal or state law that requires that the term of a "no surprises" guarantee be coextensive with the term of the HCP/NCCP. Indeed, the California Natural Communities Conservation Planning Act requires that the duration of all regulatory assurances be based on a careful assessment of the limits of scientific understanding of the covered species and their habitat:

> [CDFW's] determination of the level of assurances and the time limits specified in the implementation agreement for assurances may be based on localized conditions and shall consider:
>
> (A) The level of knowledge of the status of the covered species and natural communities.
> (B) The adequacy of analysis of the impact of take on covered species.
> (C) The use of the best available science to make assessments about the impacts of take, the reliability of mitigation strategies, and the appropriateness of monitoring techniques.
> (D) The appropriateness of the size and duration of the plan with respect to quality and amount of data.
> . . . .
> (H) The size and duration of the plan.

CAL. FISH & GAME CODE § 2820(f)(1) (2013).

183. DRAFT BDCP, at 6-48 (citing 69 Fed. Reg. 7172 (Dec. 10, 2004)).

The draft Plan states, however, that the "USFWS or NMFS will begin the revocation process only if it is determined that the continuation of a covered activity will appreciably reduce the likelihood of survival and recovery of one or more covered species and that no remedy [other than revocation] can be found and implemented."[184]

Similarly, under the California Natural Communities Conservation Planning Act, the Department of Fish and Wildlife may revoke the state incidental take permit "if necessary to avoid jeopardizing the continued existence of a listed species."[185] The federal and state fish and wildlife agencies also may revoke the permits if the Authorized Entities fail to fulfill their obligations under the BDCP, but only following the dispute resolution process set forth in the Implementing Agreement and "providing the Implementation Office and Authorized Entities with a reasonable opportunity to take appropriate responsive action."[186]

Before the fish and wildlife agencies may revoke the incidental permits, they must follow a variety of procedures and substantive standards. These include determining, in concert with the Implementation Office, "whether changes can be made to the conservation strategy . . . [and] whether there are additional voluntary implementation actions that the Authorized Entities could undertake to remedy the situation."[187]

More importantly, the draft Plan also requires the federal fish and wildlife agencies to determine whether they or some other agencies can take actions to ensure the survival of the listed species, rather than imposing such burdens on the parties to the Authorized Entities:

> The USFWS or NMFS will determine whether the fish and wildlife agencies or other state and federal agencies can undertake actions that will remedy the situation. The determination must be based on a thorough review of best available practices considering species population status and the effects of multiple federal and nonfederal actions. *It is recognized that the fish and wildlife agencies have available a wide array of authorities and resources that can be*

184. *Id.* at 6-49.

185. *Id.* at 6-49 (citing CAL. FISH & GAME CODE § 2820(c) (2013). Section 2820(c) actually addresses a more limited violation of the terms of an NCCP, providing for suspension or revocation if a plan participant fails to "maintain the proportionality between take and conservation measures specified in the implementation agreement and does not either cure the default within 45 days or enter into an agreement with the department within 45 days to expeditiously cure the default." CAL. FISH & GAME CODE § 2820(c). The more general revocation standard is set forth in section 2820(b)of the Act. *Id.* § 2820(b)(3)(A)-(D).

186. *Id.* at 6-49.

187. *Id.* at 6-48 to 6-49.

> *used to provide additional protection for the species, as do other state and federal agencies.*[188]

The draft Plan thus makes it difficult for the fish and wildlife agencies to revoke the incidental take permits if the biological objectives, conservation measures, and adaptive management changes do not achieve their primary goal of protecting and recovering the listed species. Procedural and substantive rigor is not in and of itself reason to doubt this last line of defense against extinction. But two additional facts lead us to the conclusion that permit revocation is not likely to be a credible means of ensuring the survival of the species if the BDCP fails its most essential task.

First, neither the federal fish and wildlife agencies nor the California Department of Fish and Wildlife have ever revoked an incidental take permit. Indeed, there is only one case in which a federal incidental take permit has been suspended, and that was for the permittee's violation of the terms and conditions of the habitat conservation plan, rather than because of changes in ecological conditions or the permittee's failure to agree to amendments to the biological objectives and conservation measures.[189] Revocation of the incidental take permits covered by the BCDP therefore would be an unprecedented event.

Second, a decision to revoke the incidental take permits would not be simply a scientific determination that the BDCP—as written today and implemented at some future date during its 50-year existence—is not adequate to ensure the conservation and recovery of the listed species. Although the BDCP assigns the authority to revoke the state incidental take permit to the Director of the California Department of Fish and Wildlife,[190] it stipulates that "[a]ny decision to revoke one or both federal permits must be in writing and must be signed by the Secretary of the Interior or the Secretary of Commerce, as the case may warrant."[191] In our judgment, this poses an undue risk that the revocation decision would be based on science *and* political considerations. Indeed, there would seem to be no other purpose for elevating the revocation authority from the fish and wildlife agencies to the two Cabinet-level Secretaries.

188. *Id.* at 6-48 (emphasis added).

189. *See* Letter from U.S. Fish and Wildlife Service to Victor Gonzalez, President of WindMar Renewable Energy, (Feb. 2, 2012) (decision of partial suspension of incidental take permit).

190. DRAFT BDCP, at 6-50.

191. *Id.* at 6-49. This would change the process for permit revocation set forth in the federal ESA rules, which vest revocation authority in the Director of the U.S. Fish and Wildlife Service. 50 C.F.R. § 17.22(b)(7).

For these reasons, we do not believe that the state and federal authority to revoke the incidental take permits compensates for the deficiencies in the draft BDCP described above.

D. Conclusion

We conclude that governance structure set forth in the draft BDCP is neither "transparent [nor] resilient to political and special interest influence."[192] The draft undermines the authority of the federal and state fish and wildlife agencies both by assigning them program responsibilities and by granting the Authorized Entities veto power over changes to the biological objectives, conservation measures, and adaptive management strategies that may be needed to ensure that the Plan achieves its stated goals. To address this deficiency, we recommend that the BDCP be revised to remove the Permit Oversight Group from program decisionmaking and to clarify the regulatory authority of the fish and wildlife agencies both within the BDCP and in their independent roles as principal regulators under the federal and state Endangered Species Acts and the California Natural Community Conservation Planning Act.

We also believe that the regulatory assurances contained in the draft Plan jeopardize the ability of the fish and wildlife agencies to respond to changed conditions that may require future revisions to the biological objectives and conservation measures of the BDCP. The "no surprises" guarantees—by which the state and federal governments would assume the financial costs of new infrastructure and regulatory changes in CVP/SWP operations needed to address the effects changed circumstances not provided for in the BDCP—are especially troubling. To address this problem, we recommend that the proposed 50-year "no surprises" guarantees be converted into a series of renewable guarantees—the first to cover construction of the projects authorized by the BDCP and the successors to cover project operations for sequential 10-year periods.

Finally, although the fish and wildlife agencies retain the authority to revoke the incidental take permits—and thus to rescind the BDCP—if necessary to avoid jeopardizing any listed species, the draft Plan makes it difficult to do so by requiring the federal agencies to take action against other stressors on the species before determine that it is necessary to revoking the permits. The draft also removes the revocation decision from the federal agencies themselves and places it with the Cabinet-level Secretaries in whose Department the fish and wildlife agencies are located. We believe that these heightened substantive and procedural requirements reduce the likelihood that permit revocation would serve as an effective backstop in the event that the BDCP fails to achieve its overriding purposes

192. *See* "Guiding Questions," *supra*.

of ensuring the survival and contributing to the recovery of the species. Indeed, these limitations on permit revocation strengthen our conclusions that the governance problems described throughout this chapter be repaired so that the fish and wildlife agencies retain the authority to insist on changes to the biological objectives and conservation measures of the BDCP as required to achieve species conservation and recovery.

Chapter 9: Science and Adaptive Management in BDCP

A. Introduction

From the outset BDCP makes it clear that it will be science-based and adhere to the principles of adaptive management. The plan recognizes that all 22 conservation measures that are designed to meet the plan goals and objectives face high levels of uncertainty and that measures used to implement them will inevitably require adjustment and refinement. Indeed, given the unprecedented complexity of BDCP, it will most certainly fail without substantial investments in a program of science and monitoring linked to a robust adaptive management program that allows it to change course.

At the time of this review, the science and adaptive management component of BDCP was, by the project proponents' own admission, a work in progress with many of the key elements yet to be determined. We briefly review here the available information with the understanding that these elements are likely to change, possibly considerably, before the public draft is released.

B. Adaptive Management Program

The plan documents recognize that BDCP is compelled to adhere to an array of standards for adaptive management of the program.[193] This includes requirements of USFWS and NMFS five-point policy on adaptive management,[194] NCCPA requirements for monitoring and adaptive management programs,[195] and the requirements of the Delta Reform Act for science-based adaptive management of all ecosystem and water management programs in the Delta.[196]

193. DRAFT BDCP, at 3.6-3.

194. Notice of Availability of a Final Addendum to the Handbook for Habitat Conservation Planning and Incidental Take Permitting Process ,65 Fed. Reg. 35,241, 35,24 (June 1, 2000).

195. CAL. FISH & GAME CODE § 2820(a)(7)-(8) (2013).

196. CAL. WATER CODE § 85308(f) (2013).

The BDCP documents describe the well-known adaptive management cycle involving: *plan*, where management problems are recognized leading up to a plan of action to test management actions, *do*, where plans are implemented, accompanied by monitoring, and *evaluate*, where monitoring information is evaluated to measure effectiveness, and information learned initiates anew the planning portion of the cycle. As described in BDCP, the conceptual approach to adaptive management is closely aligned to the approach codified in the Delta Plan and the draft Delta Science Plan.

Governance and Implementation of Adaptive Management

BDCP envisions that its adaptive management program will be organized and run by its Implementation Office. The office will be run by a Program Manager who will be hired by the Authorized Entity Group (AEG). The AEG will be made up of DWR, Reclamation, and the state and federal water contractors. The Program Manager selects and supervises a Science Manager, who takes on the responsibilities of running the adaptive management programs and coordinating, in unspecified ways, all science and monitoring activities.

The Science Manager will chair and manage an Adaptive Management Team (AMT) made up of a broad array of regulators, regulated entities, and science programs. These include representatives appointed by members of the AEG, the Permit Oversight Group (POG: CDFW, USFWS, NMFS), the Interagency Ecological Program (IEP), Delta Science Program (DSP), and NOAA Southwest Fisheries Science Center. This group will receive input from a Technical Facilitation Subgroup, part of a Stakeholder Council made up of multiple of stakeholder groups, regulated entities, and regulating entities.

The AMT, led by the Science Manager, will have the responsibility for designing, administering and evaluating the BDCP adaptive management program, including the development of performance measures, monitoring and research plans, synthesis of data, solicitation of independent review, and developing proposals to modify biological goals and objectives as well as conservations measures.

The AMT is to operate by consensus only, meaning all members must agree to all actions. Where consensus cannot be reached the matter is elevated to the AEG and POG for resolution. As a matter of course, all changes in conservation measures and biological goals and objectives must be approved by the POG and AEG. The entity responsible for decisionmaking (for example, NMFS regarding changes in biological goals and objectives for salmon) will decide the issue. However, as discussed in Chapter 8, *any member of the AEG or POG may request review of the decision at the highest level of the relevant federal department or state, up to the appropriate department secretary or the Governor of California*.[197]

197. DRAFT BDCP, at 7-14.

An essential goal of the adaptive management program—seeking consensus for all decisions from all regulated and regulating entities as well as key providers of science—is understandable and, if it could be achieved, laudable. However, for several reasons this is unlikely to be successful.

First, as discussed in Chapter 8, this structure confuses the roles of regulators and regulated entities. It gives exceptional decision power to regulated entities, particularly those with a great financial stake in outcomes (state and federal water contractors). We are skeptical that difficult, perhaps costly decisions could be achieved in an efficient and effective manner since *any* member of the AEG or POG can, in effect, elevate any decision, no matter how trivial, to the highest levels of government. This is likely to have a chilling effect on decisionmaking, making all parties cautious and risk-averse. These traits—caution and fear of taking risks—are antithetical to the principles of adaptive management by which all management decisions are viewed as experimental and inherently risky. The most likely outcome from this approach to governance of adaptive management is that preliminary decisions made during the initial phases of the plan are, through sheer inertia, likely to remain permanent, rendering the concept of adaptive management moot.

Second, the AMT is made up of a mix of regulators, regulated entities, and scientific providers such as IEP and DSP. This places the science providers in the position of being decisionmakers, creating clear conflicts of interest. Most importantly, as discussed below, this eliminates one of the most important aspects of science in support of adaptive management: scientific independence.

Adaptive Capacity

The AMT, with approval from the POG, AEG or higher federal and state authorities, will oversee implementation of the adaptive management program, presumably through the Science Manager. A central issue likely to arise when finalizing BDCP is the adaptive flexibility available. All such programs have a natural tension between wanting to provide assurances—such as how much water will be exported from the Delta—and needing flexibility in amount and timing of exports to test and implement adaptive management programs. The current BDCP documents offer little to no guidance on adaptive capacity. This is likely to play a major role in how adjustments are made in conservation measures and, more importantly, how real-time operations (an element of adaptive management) are implemented. BDCP has sought to defer this decision, both within the document and to its Decision Tree process (discussed below).

Science Program

Science should underpin the discussions and information needed to make and implement adaptive management decisions. The extensive literature on adaptive management cites a strong, well-funded, and well-organized science and monitoring program as essential for adaptive management. The BDCP documents do not provide extensive information about science to support adaptive management, other than a solid commitment to build and support a strong science program and, in the EIR/EIS, a significant funding commitment. As currently described, the science program would be run by the Science Manager under the direction of the Program Manager and the AEG. The role of the science manager would be to fund an array of activities, guide synthesis and analysis, and coordinate with the numerous public and private institutions working on the Delta. Beyond this, there are few specifics.

BDCP's current efforts on science have come in for extensive criticism from several entities, including the National Research Council,[198] the Delta Independent Science Board,[199] and the Public Policy Institute of California.[200] To be fair, the project proponents recognize that the BDCP science program is a work in progress and likely to change before the public draft of the plan is released. However, several significant issues will need to be resolved:

- I*ntegration*: the National Research Council in its review of Delta science was highly critical of the lack of integration of scientific efforts in the Delta. The NRC and others have pointed out that coordination is less effective than integration. BDCP is a once-in-a-generation opportunity to reorganize science in the Delta to make it more integrated and more effective for addressing the major issues of the day. As structured, BDCP builds a new stand-alone science program that seeks to coordinate with other programs, such as IEP and DSP, rather than to integrate them. This is unlikely to prove successful.
- I*ndependence*: as noted above, the AMT blurs the distinction among decision-makers, regulated entities, and the providers of science and technical advice. In addition, the BDCP science program is, in effect, run by the regulated entities and lacks independence. This creates the potential for bias in the selection of what science gets funded and what is ultimately made available to the public. Given that most major disputes in the Delta come down to differences of opinion in

198. COMM. ON SUSTAINABLE WATER & ENVTL. MGMT. IN THE CAL. BAY-DELTA, NAT'L RESEARCH COUNCIL, SUSTAINABLE WATER AND ENVIRONMENTAL MANAGEMENT IN THE CALIFORNIA BAY-DELTA (2012).

199. Memorandum from Delta Independent Science Board to Delta Stewardship Council (May 20, 2013), *available at* http://deltacouncil.ca.gov/sites/default/files/documents/files/ISB%20Comments%20on%20BDCP%20Chapter%207.pdf.

200. ELLEN HANAK ET AL., STRESS RELIEF: PRESCRIPTIONS FOR A HEALTHIER DELTA ECOSYSTEM, (2013); BRIAN GRAY ET AL., INTEGRATED MANAGEMENT OF DELTA STRESSORS: INSTITUTIONAL AND LEGAL OPTIONS (2013).

court about the best available science, demonstrating scientific integrity and transparency should be the highest priority.
- *Oversight*: as currently structured, there is no independent oversight of the BDCP science program. There is a commitment to promoting peer review of scientific work products and plans. In addition, there is mention of coordinating with the existing DSP and the Delta Independent Science Board. But oversight, which is essential for creating public assurances that the best available science is being utilized in decision-making, is currently absent from the plan.
- *Funding*: science is expensive, and for a program this large and complex, it is likely to be *very* expensive. There are no discussions regarding budget in the BDCP plan documents. However, in the administrative draft EIR/EIS there are substantial commitments to funding a science program. There are categories of funding (monitoring, research, etc.), but little information as to how it would be distributed, organized and administered. Still, this level of commitment is significant and necessary.

To be effective, during revision of the plan documents, BDCP will have to address the considerable weaknesses in science governance, integration with other programs, independence and transparency, oversight and funding. Notably, there is a parallel process underway, led by the DSC, to develop a comprehensive plan for science in the Delta. This "One Delta, One Science" effort is essential for the success of BDCP. It seems to us that BDCP's science effort should be fully integrated with the Delta Science Plan, if not led by the DSP. However, to date, BDCP has had limited involvement with this planning process.

C. Decision Tree

Earlier chapters of this review note that most controversial decisions, or decisions with high scientific uncertainty, are proposed to be resolved through adaptive management (i.e., *deferred*). One of the most important decisions will involve initial operations of the dual export facilities approximately ten years after issuance of the HCP/NCCP permit. The operations are to be based on the best available science on how to meet the co-equal goals of ecosystem benefit and water supply, with the goal of meeting the HCP/NCCP conservation standards.

A fundamental tension exists between two competing hypotheses regarding BDCP. The first, controlling hypothesis is that better management of existing export volumes with the dual facility, coupled with significant investments in floodplain, channel margin, and tidal marsh habitat to improve food webs, will improve conditions for covered species sufficiently to meet the HCP/NCCP standards. The second, embedded within the agency red flag comments and "progress reports", is that these steps are insufficient and that lower exports (higher outflow) will be needed to meet these standards. This issue is a paramount concern since it directly affects the economic viability of water supplied from the project.

As part of CM#1, BDCP will use a decision tree to address initial starting operations. As a starting point, BDCP embodies the two competing hypotheses in the LOS and HOS operating criteria, viewing them as brackets on the potential range of operations. The goal of the decision tree is to conduct a series of detailed studies and experiments to develop specific flow criteria, particularly for spring outflow (longfin smelt) and Fall X2 (delta smelt), in the decade before operation of the export facility begins.

The decision tree is the first, and probably most important, element of the BDCP adaptive management program. Much of the success of the adaptive management program will be tied to this element, since the original adaptive management and science infrastructure will presumably be built around addressing the competing hypotheses.

The decision tree approach to addressing starting operations is, in our view, laudable and appropriate. It makes no sense to wait until all uncertainties over this issue are resolved (a course of action proposed by diverse stakeholder groups). Experience says this issue will never be resolved to everyone's satisfaction and will require constant (and contentious) adaptive management. This is a necessary and appropriate step. Regrettably, there is little information given in the BDCP documents about how the decision tree would be implemented, including who would fund it, how it would be structured, how decisions would be made, what science experiments would be conducted, etc. The lack of detail about the decision tree in the BDCP documents raises several key concerns:

- It takes time to develop and implement a large, complex scientific undertaking of the kind envisioned by the decision tree approach. The POD crisis in the mid-2000's and the mobilization of the scientific community to address it is an example of a successful approach. But that still took considerable time and many issues addressed by the POD effort remain unresolved.
- To inform the potential placement and design of habitat restoration efforts to support food webs, new approaches to numerical modeling will be needed that better represent how these habitats function. Finding and funding the technical teams for this kind of work will take time and resources. A particular concern is whether contracting will be run through existing state and federal agencies who are notoriously slow at developing contracts.
- In addition, field experiments will be needed to inform and calibrate these models. This involves identifying locations to conduct experiments, modeling and designing actions, acquiring land or easements, implementing pre-project monitoring programs, implementing actions, monitoring responses, and incorporating results into system models. All of these actions take time and resources, but as is well-known by anyone working on ecosystem

restoration in the Delta, the rate-limiting step is inevitably the length of time it takes to secure permits.[201]

- Because any decision made regarding flow and habitat will have multiple, competing constituencies and regulatory interests, an extensive and often contentious public engagement effort will be needed. The history of the Delta suggests that all such significant decisions are litigated, further slowing this process.

These four concerns, as well as others, make us skeptical that the decision tree is likely to achieve the goal of resolving operations issues within a ten to fifteen year time period. We cannot say with certainty that it will not be successful. A committed, well-funded, well-managed effort on the part of all parties may yield useful conclusions. However, given that this is the less likely outcome, it seems imperative that BDCP negotiate export operations criteria that, in the absence of a successful decision tree process, will be implemented at the start of the project.

Our work in previous chapters has cast doubt on the viability of the controlling hypothesis that underpins BDCP. To this end, we think it prudent to, at minimum, adopt the HOS operating criteria as the starting condition if the decision try fails to identify operating procedures. In addition, if BDCP is truly committed to adaptive management and the use of best available science, it is not appropriate to set artificial boundaries—HOS and LOS—on the decision tree process. It is our view that the decision tree research effort should seek to define best operating procedures rather than being forced to operate within the HOS and LOS range. There is a reasonable chance that the decision tree process may ultimately determine that the HOS flow criteria are not protective enough.

D. Conclusion

The draft documentation provided by BDCP makes a strong commitment to the principles of adaptive management supported by a robust science program. Given the complexity of BDCP and the great scientific uncertainties underpinning many of the central elements of BDCP, this is absolutely necessary for success. As currently described, the BDCP adaptive management program either lacks sufficient information to be assessed or is unlikely to achieve its overall goals and objectives. This stems from two basic problems:

- The adaptive management program has a confused and conflicting governance structure that, in our view, is likely to inhibit adaptation rather than promote it.

201. *See* HANAK ET AL., *supra* note 200.

- There is insufficient information, beyond funding levels, to judge how the science program might function and how the knowledge it generates would be converted to action. The current information in the documents indicates that the program lacks integration with existing programs, scientific independence and transparency, and sufficient independent oversight.

We recommend that BDCP seek substantive engagement (beyond "coordination") with the ongoing efforts by the DSC and the Delta Stewardship Council to develop a Delta Science Plan. The goal should be to integrate BDCP science and adaptive management into the broader science infrastructure of the Delta and not to construct a new, stand-alone science organization. Additionally, BDCP needs to revisit how adaptive management decisions are made, reallocating planning and decisionmaking authorities.

The decision tree process that seeks to resolve issues over initial operating criteria and habitat restoration investments is both appropriate and necessary. Unfortunately only limited information is available about this program so we cannot evaluate it. We are confident, however, that it is unlikely to resolve the major issues over the trade-offs between flow and ecosystem investments. For this reason, in the absence of resolution of decision tree process starting operations should be similar to HOS criteria.

Chapter 10: Summary and Recommendations

A. Introduction

We present a narrow review of aspects of BDCP that relate to conservation of federally listed fishes. We identify both strengths and weaknesses of BDCP's conservation measures in its effort to balance water supply reliability with ecosystem goals and objectives. Due to time and resource limits this review is incomplete. We did not examine all issues associated with aquatic ecosystems. For example, we did not evaluate habitat restoration on the San Joaquin River. Nor did we evaluate conservation issues for all covered fishes, giving limited attention to Sacramento splittail, San Joaquin steelhead, sturgeon and lamprey. Instead, we focused on the conservation measures that affect winter-run and spring-run Chinook salmon, delta smelt, and longfin smelt, because these measures are the most controversial and have greatest impacts on water supply operations. We also focused on a limited subset of the alternatives listed in BDCP documentation: the Early Long Term conditions under a No-

Action Alternative (NAA), Low Outflow Scenario (LOS) and High Outflow Scenario (HOS).[202]

We summarize our findings on the six guiding questions identified in Chapter 1, plus several recommendations sought by the NGOs after we began our work. These are intended to help inform The Nature Conservancy and American Rivers in their engagement efforts with BDCP. Where appropriate, we describe alternative approaches that might be taken for BDCP to more effectively meet its goals. On many issues we have no recommendations.

B. Question 1: Operations

Do operations of the dual facilities meet the broader goal of taking advantage of wet and above average years for exports while reducing pressure on below average, dry and critically dry years? What substantive changes in operations (and responses, see below) are there both seasonally and interannually?

We analyzed the CALSIM data on export operations under NAA , HOS and LOS for ELT conditions. We note that the modeling of flows under BDCP has three compounding uncertainties: uncertainty over system understanding and future conditions; model uncertainties associated with CALSIM, DSM2 and UnTrim; and, behavioral/regulatory uncertainty, where the model cannot fully capture operational flexibility. For this reason, model outputs should be viewed as approximations useful for comparing different scenarios rather than as a predictor of future conditions. This issue influences all of our conclusions.

Based on our review we conclude:

- The array of existing and projected flow regulations significantly constrains operations in BDCP. The assumed operational flexibility associated with new North Delta facility is limited.
- HOS and LOS operations promote greater export during wet periods through increased use of North Delta diversions during the winter and spring. During dry and critical years, there is not much difference in *average* exports compared to NAA. For this reason, BDCP generally fails to meet the broader objective of reducing pressure on the Delta during dry periods.
- In some dry periods regulatory controls on OMR flows and North Delta diversions lead to significant increases in outflow and OMR

202. NAA ELT is the no-project alternative using the 2008, 2009 BiOps with high spring outflow, 2025 climate and sea level conditions. LOS is with-project alternative with low fall and spring outflow, 2025 climate and sea level conditions. HOS is with-project alternative with high spring and fall outflow standards, 2025 climate and sea level conditions.

flows over NAA. These unexpected results are the consequence of stricter flow requirements for HOS and LOS and operations being tied to previous water-year type in the fall and early winter. We are unsure if the project would actually be operated this way under these conditions.

- We evaluated how NAA, HOS and LOS performed during extended droughts. Of the three scenarios, HOS appears to be most protective of both supply and ecosystems by reducing the frequency and duration of dead pool conditions on Sacramento Valley reservoirs and assuring higher spring and fall outflows.

Recommendations: caution must be used in interpreting CALSIM model results for both export and environmental performance of BDCP due to compounding uncertainties. However, modeling results suggest that overall flow conditions are improved over NAA.

C. Question 2: Impacts of North Delta Facility

Based on operations criteria, does the Plan properly identify ecological impacts likely to occur adjacent to and in the bypass reach downstream of the new North Delta diversion facilities? If there will be direct and indirect harm to listed species by the facilities, does the Plan prescribe sufficient mitigation measures?

We reviewed the Conservation Measures and Effects Analysis of BDCP, including supporting appendices to evaluate conditions upstream of the North Delta facility, as well as near- and far-field effects of the facility itself. Our focus was on winter- and spring-run Chinook salmon, rather than all covered species. Based on this review we conclude:

- The BDCP consultants have appropriately identified the range of impacts on listed salmon likely to be associated with the operations of the North Delta facility. These include near-field effects such as impingement on intake screens and high predation losses at the facility, to far-field effects such as reduced survivorship of juvenile salmon due to higher transit times and redirection into the interior Delta. Using multiple modeling approaches, they have created reasonable estimates of losses due to operation of the facility.
- Mitigation for take associated with the new facility includes restricting diversion flows during initial pulse flows in the river, predator control, nonphysical barriers, real-time operations to protect outmigrants, and modification of the Fremont Weir to divert fish onto the Yolo Bypass. With the possible exception of benefits from Fremont Weir modifications the uncertainties over mitigation actions are all high.
- We see high potential value in the Yolo Bypass for mitigating the effects of North Delta diversions on juvenile salmon, particularly in drier conditions. Therefore, existing adaptive management programs

on the Bypass must be supported, with accelerated pilot studies, monitoring and ecological modeling, to ensure success of any modifications of the Bypass.

- Mitigation is hampered by the lack of a viable adaptive management plan or real-time management plan in the current BDCP for the North Delta facility. Still, even with these uncertainties, if managed well, fully implemented and functioning as described in the plan, the actions appear to mitigate for losses associated with the North Delta facilities.
- These mitigation efforts alone are unlikely to lead to significant increases in salmon populations, and extinction risk remains high for winter- and spring-run Chinook salmon, particularly during extended drought and warm periods when reservoirs are low. However, reservoir management is not within the scope of BDCP.

Recommendations: given the uncertainties over mitigation for the North Delta facility, we recommend that all mitigation actions be evaluated and completed prior to initiating operations the North Delta facility. Of highest priority is to bolster and complete adaptive management activities in progress on the Yolo Bypass. Additionally, we recommend establishing an adaptive management and real-time management program with the capacity to conduct significant experiments in flow management, predator control, and nonphysical barrier implementation *prior* to initiating facility operation. These should be conditions of the HCP/NCCP take permit.

D. Question 3: In-Delta Conditions

Are changes in operations and points of diversion prescribed in the Plan sufficient to significantly improve in-Delta conditions for covered species? The focus is on listed species, including delta and longfin smelt, steelhead, winter and spring run Chinook, and green sturgeon.

We focused our analysis on in-Delta conditions that may affect delta smelt and longfin smelt. We reviewed the effects analysis and supporting documentation and conducted our own modeling based on CALSIM output. Based on this work we conclude:

- The CALSIM output we used showed conditions that appeared anomalous based on our understanding of how the system would actually be operated. Although we have been assured that these conditions were logical consequences of model design and operation to meet flow requirements, we remain unconvinced that they reflect actual future operations under the hydrologic conditions simulated. We therefore caution that **the conclusions below are contingent upon the actual operations of the system resembling those in the model output.** They are also contingent on the biological models accurately reflecting responses of the species to flow conditions.

- Roughly half of the export from the Delta will go through the North Delta facility. In addition, OMR flow regulations are more restrictive (protective) under HOS and LOS scenarios than NAA. Thus the incidence of positive OMR flows rose from 11% under NAA to 16% under HOS and LOS conditions. HOS and LOS are consistently more protective of smelt than NAA under these modeling assumptions.
- OMR flow regulation under HOS and LOS for October through January is governed by previous water year type. This leads to anomalously high (positive) OMR flows and corresponding outflow during some dry periods, creating apparent benefits for delta smelt. We are uncertain if this would manifest in real operations.
- Entrainment results in fractional population losses of delta smelt that can be calculated from modeled flow conditions. Based on these calculations, we estimate that HOS and LOS reduced fractional population losses by half compared to NAA. If actual operations were similar to the model results, they would lead to significant decreases in entrainment.
- Estimates of relative differences in long-term survival percentages (not predictions) showed a 19-fold increase for HOS and 11-fold increase for LOS over NAA, albeit with large uncertainty. A difference of this magnitude over the last 20 years would have reversed the decline of delta smelt in the 2000s.
- Increases in spring outflow are projected by the models to produce only a very small increase in longfin smelt abundance index under HOS compared to NAA, and a comparable decrease under LOS.
- Increases in fall outflow under HOS are projected to produce a small increase in recruitment by the following summer, and under LOS a modest decrease, but because of high variability in the data used to make these predictions, these values are very uncertain.

Recommendations: we remain uncertain about significant reduction in fractional population losses of delta smelt under the new HOS and LOS operating criteria. We recommend investment in resolving these uncertainties before operations are finalized. If these relationships are supported, then operational rules need to be refined to protect the benefits of these improvements over a broad range of conditions.

E. Question 4: Benefits of Habitat Restoration

Are covered pelagic fish like longfin smelt and delta smelt likely to benefit from restoration of floodplain and tidal marsh habitat at the scale proposed by the Plan? *Given the current state of knowledge, and assuming that all* Plan *commitments are met, are these efforts likely to result in relaxed* X2 *and spring outflow standards*?

A fundamental hypothesis embedded in the BDCP goals and objectives is that improvements in physical habitat, particularly floodplain and tidal marsh, will improve conditions for covered fishes. We focused our assessment on the relationship between habitat restoration and longfin and delta smelt. Based on this analysis we conclude:

- BDCP correctly identifies food limitation as a significant stressor on delta and longfin smelt, particularly in spring through fall. Increasing food availability in smelt rearing areas would likely lead to increases in population.
- Tidal marshes can be sources or sinks for phytoplankton and zooplankton. Most appear to be sinks, particularly for zooplankton. There is high on-site consumption of productivity within marshes.
- Even under the most highly favorable assumptions, restored marshes would have at best a minor contribution to plankton production in smelt rearing areas.
- Smelt can benefit by having direct access to enhanced productivity. This is likely the case for the subpopulation of smelt that reside in Cache Slough.
- BDCP is too optimistic about benefits of tidal marsh and floodplain restoration for smelt, particularly the extent of food production. These optimistic views are indirectly guiding the LOS outflow criteria. There is no clear connection, however, between the two and investments in marsh restoration are unlikely to lead to reduced demand for outflows.

Recommendations: it is possible but unlikely that marsh restoration will materially improve conditions for smelt, although other ecosystem and species benefits of marsh restoration are much more likely. Only moderate- to large-scale experimental restoration projects are likely to resolve this uncertainty and to help in designing future efforts. BDCP should design and describe a specific program to resolve this issue. Until this uncertainty is resolved flow management will remain the principal tool to mitigate project impacts.

F. Question 5: Governance

Does the Plan provide achievable, clear and measurable goals and objectives, as well as governance that is transparent and resilient to political and special interest influence?

We analyzed the proposed governance structure of BDCP, including the responsibilities and authorities of new entities such as the Authorized Entity Group (AEG), the Permit Oversight Group (POG), the Adaptive Management Team (AMT), Implementation Office, Program Manager and Program Scientist. Based on this review we conclude the following:

- The governance plan, as structured, blurs the responsibilities between implementation and regulation. It grants AEG final decisionmaking power over actions that should be solely within the authority of the permitting agencies. It also involves the permitting agencies too heavily in implementation of the project.

- As written, the plan grants the AEG veto authority over proposed changes in the program, including any changes in biological goals and objectives or conservation measures.
- The AEG has the power to veto any minor modification, revision or amendment to the Plan that may be necessary to manage listed species.
- The regulatory assurances set forth in the draft Plan severely constrain the fish agencies' ability to respond to inadequacies in biological objectives.
- Given the high uncertainties inherent in BDCP, it is very likely that unforeseen circumstances will require significant changes in biological goals and objectives and conservation actions. Under the 50-year "no surprises" guarantee, the fish agencies assume financial responsibility for many significant changes. This liability could deter needed regulatory changes to BDCP and CVP/SWP operations.
- The procedural hurdles necessary to revoke the incidental take permit of BDCP are so great that revocation is unlikely to occur over the 50-year life of the permit. Indeed, permit revocation and termination of the BDCP would be unprecedented under both state and federal law.

Recommendations: The POG should be granted exclusive regulatory authority to determine whether budgets and workplans are consistent with the permit and to approve revisions to the biological goals and objectives or amendments to the plan. It should have the authority to initiate changes needed to insure protection of the covered species. The POG's functions should be limited to regulatory oversight rather than direct involvement in implementation. There should be a "no surprises" guarantee for construction of the project. Upon completion of the project, there should be renewable "no surprises" guarantees every ten years. These renewals should be based on conditions at the time of renewal and appropriateness of biological goals and objectives. This approach creates an incentive for all parties to adapt to changes in conditions to sustain covered species, rather than simply fulfilling obligations on conservation measures.

G. Question 6: Science and Adaptive Management

Is there a robust science and adaptive management plan for BDCP? *As described, is the proposed "decision tree" likely to resolve major issues regarding* Fall X2 *and* Spring Outflow *prior to initial operations*?

We reviewed the science and adaptive management plans in both the plan and EIS/EIR documents. Most issues with high uncertainty or controversy in the Plan are relegated to resolution through an adaptive management process. Based on the documentation, we conclude:

- Given the major uncertainties facing BDCP a robust, well-organized and nimble adaptive management plan will be necessary. The current plan adheres to and strongly promotes the principles of adaptive management and science.
- The requirement of unanimous consent for all decisions by the AMT, and veto power of any member of the AEG and POG is a barrier to adaptive management.
- There is a blurring of the responsibilities between regulators and those responsible for implementation of adaptive management that has the potential to create conflicts. There is a conflicting relationship between AMT decisionmaking and the scientific organizations providing support for decisonmaking.
- The plan recognizes the importance of adaptive capacity, meaning flexibility in operations and actions that allow for learning. Yet it does not describe this capacity in a meaningful way.
- There is almost no description of a science program. What is provided lacks evidence for integration with existing programs, transparency, independence from bias and influence, and structured oversight. These are all necessary for success.
- The decision tree process to establish initial operating conditions is appropriate. Done well, it can resolve many issues. However, it is unlikely to resolve the central issue over starting conditions in time to implement them.
- Although difficult decisions are relegated to a future adaptive management program, actually implementing such a program on such a scale will be very difficult and will require careful design. BDCP does not provide information sufficient to determine whether it will be effective. We remain skeptical that it will.

Recommendations: many of the recommendations for changes in governance made previously will go a long way toward improving the adaptive management program, including the separation of regulators from implementation efforts. However, the plan still needs a complete description of how its adaptive management program would function. The AMT, in whatever form it takes, should be advised by a science program, without scientists responsible for decisionmaking. The science program should be integrated with existing Delta science programs, rather than inventing a new parallel program. The best opportunity for integration is the current efforts to establish a Delta Science Plan through the Delta Science Program and Delta Stewardship Council. Given that the decision tree is unlikely to fully reduce uncertainties in time, coupled with our concerns over how the project would be operated rather than modeled, we recommend that default starting operating conditions be negotiated that approximates the HOS scenario, with a goal of identifying and operationalizing attributes of this scenario that are most beneficial to listed fishes.

* * *